
IL ME SUIT PARTOUT
John Walton.

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OR, A

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Material, Materialists.

MATERIAL, denotes something composed of *matter*. In which sense the word stands opposed to *immaterial*. See MATTER and METAPHYSICS.

MATERIALISTS, a sect in the ancient church, composed of persons who, being prepossessed with that maxim in the ancient philosophy, *Ex nihilo nihil fit*, "Out of nothing nothing can arise," had recourse to an internal matter, on which they supposed God wrought in the creation; instead of admitting God alone as the sole cause of the existence of all things. Tertullian vigorously opposes the doctrine of the materialists in his treatise against Hermogenes, who was one of their number.

Materialists.

MATERIALISTS is also a name given to those who maintain that the soul of man is material; or that the principle of perception and thought is not a substance distinct from the body, but the result of corporeal organization: See METAPHYSICS. There are others, called by this name, who have maintained that there is nothing but matter in the universe; and that the Deity himself is material. See SPINOZA.

MATHEMATICS.

Definition of mathematics.

MATHEMATICS is divided into two kinds, *pure* and *mixed*. In *pure mathematics* magnitude is considered in the abstract; and as they are founded on the simplest notions of quantity, the conclusions to which they lead have the same evidence and certainty as the elementary principles from which these conclusions are deduced. This branch of mathematics comprehends, 1. *Arithmetic*, which treats of the properties of numbers. 2. *Geometry*, which treats of extension as endowed with three dimensions, length, breadth, and thickness, without considering the physical qualities inseparable from bodies in their natural state. 3. *Algebra*, sometimes called universal arithmetic, which compares together all kinds of quantities, whatever be their value. 4. The *direct and inverse method of Fluxions*, (called on the continent, the *differential* and *integral calculi*), which consider magnitudes as divided into two kinds, constant and variable, the variable magnitudes being generated by motion; and which determines the value of quantities from the velocities of the motions with which they are generated. *Mixed Mathematics* is the application of pure mathematics to certain established physical principles, and comprehends all the physico-mathematical sciences, namely, 1. *Mechanics*; 2. *Hydrodynamics*; 3. *Optics*; 4. *Astronomy*; 5. *Acoustics*; 6. *Electricity*; and, 7. *Magnetism*. The history of these various branches of science having been given at full length, we shall at present direct the attention of the reader to the origin and progress of pure mathematics.

2. In attempting to discover the origin of arithmetic and geometry, it would be a fruitless task to conduct the reader into those ages of fable which preceded the records of authentic history. Our means of information upon this subject are extremely limited and imperfect; and it would but ill accord with the dignity of a science whose principles and conclusions are alike irresistible, to found its history upon conjecture and fable. But notwithstanding this obscurity in which the early history of the sciences is enveloped, one thing appears certain, that arithmetic and geometry, and some of the physical sciences, had made considerable progress in Egypt, when the mysteries and the theology of that favoured kingdom were transplanted into Greece. It is highly probable that much natural and moral knowledge was taught in the Eleusinian and Dionysian mysteries, which the Greeks borrowed from the Egyptians, and that several of the Grecian philosophers were induced by this circumstance to travel into Egypt, in search of those higher degrees of knowledge, which an acquaintance with the Egyptian mysteries had taught them to anticipate. We accordingly find Thales and Pythagoras successively under the tuition of the Egyptian priests, and returning into Greece loaded with the intellectual treasures of Egypt. By the establishment of the Ionian school at Miletus, Thales instructed his countrymen in the knowledge which he had received, and gave birth to that spirit of investigation and discovery with which his followers were inspired. He taught them the method of ascertaining the height of the pyramids of Memphis by the length of their shadows; and there is reason to believe that he was the first

The sciences originated in Egypt.

A. C. 640. A. C. 590.

Discoveries of Thales.

first who employed the circumference of a circle for the mensuration of angles. That he was the author of greater discoveries, which have been either lost or ascribed to others, there can be little doubt; but these are the only facts in the history of Thales which time has spared.

Discoveries of Pythagoras.

3. The science of arithmetic was one of the chief branches of the Pythagorean discipline. Pythagoras attached several mysterious virtues to certain combinations of numbers. He swore by *four*, which he regarded as the chief of numbers. In the number *three* he supposed many wonderful properties to exist; and he regarded a knowledge of arithmetic as the chief good. But of all Pythagoras's discoveries in arithmetic, none have reached our times but his multiplication table. In geometry, however, the philosopher of Samos seems to have been more successful. The discovery of the celebrated proposition which forms the 47th of the first book of Euclid's Elements, that in every right-angled triangle the square of the side subtending the right angle is equal to the sum of the squares of the other two sides, has immortalized his name; and whether we consider the inherent beauty of the proposition, or the extent of its application in the mathematical sciences, we cannot fail to class it among the most important truths in geometry. From this proposition its author concluded that the diagonal of a square is incommensurate to its side; and this gave occasion to the discovery of several general properties of other incommensurate lines and numbers.

4. In the time which elapsed between the birth of Pythagoras and the destruction of the Alexandrian school, the mathematical sciences were cultivated with great ardour and success. Many of the elementary propositions of geometry were discovered during this period; but history does not enable us to refer each discovery to its proper author. The method of letting fall a perpendicular upon a right line from a given point (Euclid, B. I. prop. xi.);—of dividing an angle into two equal parts, (Euclid, B. I. prop. ix.); and of making an angle equal to a given angle, (Euclid, B. I. prop. xxiii.) were invented by Oenopidus of Chios. About the same time Zenodorus, some of whose writings have been preserved by Theon in his commentary on Ptolemy, demonstrated, in opposition to the opinion then entertained, that isoperimetrical figures have equal areas. Coeval with this discovery was the theory of regular bodies, for which we are indebted to the Pythagorean school.

Discoveries of Oenopidus and Zenodorus.

The celebrated problem of the duplication of the cube proposed and investigated.

5. About this time the celebrated problem of the duplication of the cube began to occupy the attention of the Greek geometers. In this problem it was required to construct a cube whose solid content should be double that of a given cube; and the assistance of no other instrument but the rule and compasses was to be employed. The origin of this problem has been ascribed by tradition to a demand of one of the Grecian deities. The Athenians having offered some affront to Apollo, were afflicted with a dreadful pestilence; and upon consulting the oracle at Delos, received for answer, *Double the altar of Apollo.* The altar alluded to happened to be cubical; and the problem, supposed to be of divine origin, was investigated with ardour by the Greek geometers, though it afterwards baffled all their acuteness. The solution of this difficulty was attempted by Hippocrates of Chios. He discovered, that if

A. C. 450.

two mean proportionals could be found between the side of the given cube, and the double of that side, the first of these proportionals would be the side of the cube sought. In order to effect this, Plato invented an instrument composed of two rules, one of which moved in grooves cut in two arms at right angles to the other, so as always to continue parallel with it; but as this method was mechanical, and likewise supposed the description of a curve of the third order, it did not satisfy the ancient geometers. The doctrine of conic sections, which was at this time introduced into geometry by Plato, and which was so widely extended as to receive the name of the *higher geometry*, was successfully employed in the problem of doubling the cube. Menechmus found that the two mean proportionals mentioned by Hippocrates, might be considered as the ordinates of two conic sections, which being constructed according to the conditions of the problem, would intersect one another in two points proper for the solution of the problem. The question having assumed this form, gave rise to the theory of geometrical loci, of which so many important applications have been made. In doubling the cube, therefore, we have only to employ the instruments which have been invented for describing the conic sections by one continued motion. It was afterwards found, that instead of employing two conic sections, the problem could be solved by the intersection of the circle of the parabola. Succeeding geometers employed other curves for this purpose, such as the conchoid of Nicomedes and the cissoid of Diocles, &c. An ingenious method of finding the two mean proportionals, without the aid of the conic sections, was afterwards given by Pappus in his mathematical collections.

Conic sections discovered by Plato. A. C. 390.

A. C. 280. A. C. 460. A. D. 400.

6. Another celebrated problem, to trisect an angle, was agitated in the school of Plato. It was found that this problem depended upon principles analogous to those of the duplication of the cube, and that it could be constructed either by the intersection of two conic sections, or by the intersection of a circle with a parabola. Without the aid of the conic sections, it was reduced to this simple proposition:—To draw a line to a semicircle from a given point, which line shall cut its circumference, and the prolongation of the diameter that forms its base, so that the part of the line comprehended between the two points of intersection shall be equal to the radius. From this proposition several easy constructions may be derived. Dinostratus of the Platonic school, and the cotemporary of Menechmus, invented a curve by which the preceding problem might be solved. It had the advantage also of giving the multiplication of an angle, and the quadrature of the circle, from which it derived the name of quadratrix.

The trisection of an angle.

7. While Hippocrates of Chios was paving the way for the method of doubling the cube, which was afterwards given by Pappus, he distinguished himself by the quadrature of the lunulæ of the circle; and had from this circumstance the honour of being the first who found a curvilineal area equal to a space bounded by right lines. He was likewise the author of Elements of Geometry, a work, which, though highly approved of by his cotemporaries, has shared the same fate with some of the most valuable productions of antiquity.

Hippocrates's lunula. A. C. 450.

8. After the conic sections had been introduced into geometry by Plato, they received many important additions from Eudoxus, Menechmus, and Aristeus. The latter

A. C. 380. latter of these philosophers wrote *five* books on conic sections, which, unfortunately for science, have not A. C. 300. reached our times.

Elements of Euclid. 9. About this time appeared Euclid's Elements of Geometry, a work which has been employed for 2000 years in teaching the principles of mathematics, and which is still reckoned the most complete work upon the subject. Peter Ramus has ascribed to Theon both the propositions and the demonstrations in Euclid. It has been the opinion of others that the propositions belong to Euclid, and the demonstrations to Theon, while others have given to Euclid the honour of both. It seems most probable, however, that Euclid merely collected and arranged the geometrical knowledge of the ancients, and that he supplied many new propositions in order to form that chain of reasoning which runs through his elements. This great work of the Greek geometer consists of fifteen books: the eleven first books contain the elements of pure geometry, and the rest contain the general theory of ratios, and the leading properties of commensurate and incommensurate numbers.

Discoveries of Archimedes. A. C. 250. 10. Archimedes, the greatest geometer among the ancients, flourished about half a century after Euclid. He was the first who found the ratio between the diameter of a circle and its circumference; and, by a method of approximation, he determined this ratio to be as 7 to 22. This result was obtained by taking an arithmetical mean between the perimeters of the inscribed and circumscribed polygon, and is sufficiently accurate for every practical purpose. Many attempts have since been made to assign the precise ratio of the circumference of a circle to its diameter; but in the present state of geometry this problem does not seem to admit of a solution. The limits of this article will not permit us to enlarge upon the discoveries of the philosopher of Syracuse. We can only state, that he discovered the superficies of a sphere to be equal to the convex surface of the circumscribed cylinder, or to the area of four of its great circles, and that the solidity of the sphere is to that of the cylinder as 3 to 2. He discovered that the solidity of the paraboloid is one half that of the circumscribed cylinder, and that the area of the parabola is two thirds that of the circumscribed rectangle; and he was the first who pointed out the method of drawing tangents and forming spirals. These discoveries are contained in his works on the dimension of the circle, on the sphere and cylinder, on conoids and spheroids, and on spiral lines. Archimedes was so fond of his discovery of the proportion between the solidity of the sphere and that of the cylinder, that he ordered to be placed upon his tomb a sphere inscribed in a cylinder, and likewise the numbers which express the ratio of these solids.

Discoveries of Apollonius. A. C. 200. 11. While geometry was thus advancing with such rapid steps, Apollonius Pergæus, so called from being born at Perga in Pamphylia, followed in the steps of Archimedes, and widely extended the boundaries of the science. In addition to several mathematical works, which are now lost, Apollonius wrote a treatise on the theory of the conic sections, which contains all their properties with relation to their axes, their diameters, and their tangents. He demonstrated the celebrated theorem, that the parallelogram described about the two conjugate diameters of an ellipse or hyperbola is equal to the rectangle described round the two axes, and that the sum or difference of the squares of the two conjugate diameters are equal to the sum or difference of the squares of the two axes. In his fifth book he determines the greatest and the least lines that can be drawn to the circumferences of the conic sections from a given point, whether this point is situated in or out of the axis. This work, which contains everywhere the deepest marks of an inventive genius, procured for its author the appellation of the *Great Geometer*.

12. There is some reason to believe, that the Egyptians were a little acquainted with plane trigonometry; and there can be no doubt that it was known to the Greeks. Spherical trigonometry, which is a more difficult part of geometry, does not seem to have made any progress till the time of Menelaus, an excellent geometrician and astronomer. In his work on spherical triangles, he gives the method of constructing them, and of resolving most of the cases which were necessary in the ancient astronomy. An introduction to spherical trigonometry had already been given to the world by Theodosius in his Treatise on Spherics, where he examines the relative properties of different circles formed by cutting a sphere in all directions. Menelaus writes on spherical triangles. A. D. 55. Theodosius's spherics. A. C. 60.

13. Though the Greeks had made great progress in the science of geometry, they do not seem to have hitherto considered quantity in its general or abstract state. In the writings of Plato we can discover something like traces of geometrical analysis; and in the seventh proposition of Archimedes's work on the sphere and the cylinder, these traces are more distinctly marked. He reasons about unknown magnitudes as if they were known, and he finally arrives at an analogy, which, when put into the language of algebra, gives an equation of the third degree, which leads to the solution of the problem. Progress of analysis.

14. It was reserved, however, for Diophantus to lay the foundation of the modern analysis, by his invention of the analysis of indeterminate problems; for the method which he employed in the resolution of these problems has a striking analogy to the present mode of resolving equations of the 1st and 2d degrees. He was likewise the author of thirteen books on arithmetic, several of which are now lost. The works of Diophantus were honoured with a commentary by the beautiful and learned Hypatia, the daughter of Theon. The same A. D. 410. fanaticism which led to the murder of this accomplished female was probably the cause that her works have not descended to posterity. The analysis of indeterminate problems invented by Diophantus. A. D. 350.

15. Near the end of the fourth century of the Christian era, Pappus of Alexandria published his mathematical collections, a work which, besides many new propositions of his own, contains the most valuable productions of ancient geometry. Out of the eight books A. D. 400. of which this work consisted, two have been lost; the rest are occupied with questions in geometry, astronomy, and mechanics. Mathematical collections of Pappus.

16. Diocles, whom we have already had occasion to mention as the inventor of the cissoid, discovered the solution of a problem proposed by Archimedes, viz. to cut a sphere by a plane in a given ratio. The solution of Diocles has been conveyed to us by Eutocius, who wrote commentaries on some of the works of Archimedes and Apollonius, A. D. 520. About the time of Discoveries of Diocles.

and Serenus. of Diocles flourished Serenus, who wrote two books on the cylinder and cone, which have been published at the end of Halley's edition of Apollonius.

Labours of Proclus. A. D. 500. 17. Geometry was likewise indebted to Proclus, the head of the Platonic school at Athens, not only from his patronage of men of science, but his commentary on the first book of Euclid. Mathematics were also cultivat- by Marinus, the author of the Introduction to Euclid's Data;—by Isidorus of Miletus, who was a disciple of Proclus, and by Hero the younger, whose work, entitled Geodesia, contains the method of determining the area of a triangle from its three sides.

Destruction of the Alexandrian library. 18. While the mathematical sciences were thus flourishing in Greece, and were so successfully cultivated by the philosophers of the Alexandrian school, their very existence was threatened by one of those great revolutions with which the world has been convulsed. The dreadful ravages which were committed by the successors of Mahomet in Egypt, Persia, and Syria, the destruction of the Alexandrian library by the caliph Omar, and the dispersion of a number of those illustrious men who had flocked to Alexandria as the cultivators of science, gave a deadly blow to the progress of geometry. Revival of science. When the fanaticism of the Mahometan religion, however, had subsided, and the termination of war had turned the minds of the Arabs to the pursuits of peace, the arts and sciences engaged their affection, and they began to kindle those very intellectual lights which they had so assiduously endeavoured to extinguish. The works of the Greek geometers were studied with care; and the arts and sciences reviving under the auspices of the Arabs, were communicated in a more advanced condition to the other nations of the world.

19. The system of arithmetical notation at present adopted in every civilized country, had its origin among A. D. 960. the Arabs. Their system of arithmetic was made known to Europe by the famous Gerbert, afterwards Pope Sylvester II. who travelled into Spain when it was under the dominion of that nation.

20. The invention of algebra has been ascribed to the Arabs by Cardan and Wallis, from the circumstance of their using the words *square*, *cube*, *quadrato-quadratum*, &c. instead of the 2d, 3d, 4th, &c. powers as employed by Diophantus. But whatever truth there may be in this supposition, it appears that they were able to resolve cubic, and even biquadratic equations, as there is in the Leyden library, an Arabic MS. entitled "The Algebra of Cubic Equations, or the Solution of Solid Problems."

Progress of the Arabs in geometry. 21. The various works of the Greek geometers were translated by the Arabs, and it is through the medium of an Arabic version, that the fifth and sixth books of Apollonius have descended to our times. Mahomet Ben Musa, the author of a work on Plane and Spherical Figures, and Geber Ben Aphla, who wrote a commentary on Plato, gave a new form to the plane and spherical trigonometry of the ancients. By reducing the theory of triangles to a few propositions, and by substituting, instead of the chords of double arcs, the sines of the arcs themselves, they simplified this important branch of geometry, and contributed greatly to the abridgement of astronomical calculation. A treatise on the art of surveying was likewise written by Mahomet of Bagdad.

22. After the destruction of the Alexandrian school founded by Lagus, one of the successors of Alexander, the dispersed Greeks continued for a while to cultivate their favourite sciences, and exhibited some marks of that genius which had inspired their forefathers. The *magic squares* were invented by Moschopulos, a discovery more remarkable for its ingenuity than for its practical use. Moschopulos's discovery of the magic squares. The same subject was afterwards treated by Cornelius Agrippa in his work on occult philosophy; by Bachet de Meziriac, a learned algebraist, about the beginning of the 17th century, and in later times by Frenicle de Bessi, M. Poignard of Brussels, De la Hire, and Sauveur.

23. The science of pure mathematics advanced with a doubtful pace during the 13th, 14th, and 15th centuries. Algebra introduced into Italy by Leonard of Pisa 1202, 1228. The algebra of the Arabians was introduced into Italy by Leonard of Pisa, who, in the course of his commercial speculations in the east, had considerable intercourse with the Arabs. A work on the Plani sphere, and ten books on arithmetic, were written by Jordanus Nemorarius. The Elements of Euclid were A.D. 1230. translated by Campanus of Novara. A.D. 1250. A work on algebra, entitled *Summa de Arithmetica, Geometria, Proportione et Proportionalitate*, was published by Lucas Paccioli; and about the same time appeared Regiomontanus's treatise on trigonometry, which contains the method of resolving spherical triangles in general, when A.D. 1494. the three angles or three sides are known.

24. During the 16th century, algebra and geometry advanced with rapidity, and received many new discoveries from the Italian philosophers. The formula for A.D. 1505. the solution of equations of the third degree was dis- A.D. 1535. covered by Scipio Ferri professor of mathematics at Bologna, and perhaps by Nicholas Tartalea of Brescia; and equations of the fourth order were resolved by Lewis Ferrari, the disciple of Hieronymus Cardan of Bononia. This last mathematician published nine books of arithmetic in 1539; and in 1545, he added a tenth, containing the doctrine of cubic equations which he had received in secrecy from Tartalea, but which he had so improved as to render them in some measure his own. The common rule for solving cubic equations still goes by the name of Cardan's Rule.

Discoveries of Bombelli. A.D. 1579. 25. The irreducible case in cubic equations was successfully illustrated by Raphael Bombelli of Bologna. He has shown in his algebra, what was then considered as a paradox, that the parts of the formula which represents each root in the irreducible case, form, when taken together, a real result; but the paradox vanished when it was seen from the demonstration of Bombelli that the imaginary quantities contained in the two numbers of the formula necessarily destroyed each other by their opposite signs. Labours of Maurolycus. Born 1494. Died 1579. About this time Maurolycus, a Sicilian mathematician, discovered the method of summing up several serieses of numbers, such as the series 1, 2, 3, 4, &c.; 1, 4, 9, 16, &c. and the series of triangular numbers, 1, 3, 6, 10, 15, 21, &c.

Discoveries of Vieta. Born 1540. Died 1603. 26. The science of analysis is under great obligations to Francis Vieta, a native of France. He introduced the present mode of notation, called *literal*, by employing the letters of the alphabet to represent indefinite given quantities; and we are also indebted to him for the method of transforming one equation into another, whose roots are greater or less than those of the original equation by a given quantity; for the method of multiplying or dividing their roots by any given number,

ber, of depriving equations of the second term, and of freeing them from fractional coefficients. The method which he has given for resolving equations of the third and fourth degree is also new and ingenious, and his mode of obtaining an approximate solution of equations of every order is entitled to still higher praise. We are also indebted to Vieta for the theory of angular sections, the object of which is to find the general expressions of the chords or sines for a series of arcs that are multiples of each other.

Logarithms invented by Baron Napier. Born 1550. Died 1617.

27. While analysis was making such progress on the continent, Baron Napier of Merchiston in Scotland was bringing to perfection his illustrious discovery of the *logarithms*, a set of artificial numbers, by which the most tedious operations in multiplication and division may be performed merely by addition and subtraction. This discovery was published at Edinburgh in 1614 in his work entitled *Logarithmorum Canonis Descriptio, seu Arithmetica Supputationum Mirabilis Abbreviatio.* It is well known that there is such a correspondence between every arithmetical and geometrical progression, viz. $\left\{\begin{matrix}0, & 1, & 2, & 3, & 4, & 5, & 6,\\ 1, & 2, & 4, & 8, & 16, & 32, & 64,\end{matrix}\right\}$ that any terms of the geometrical progression may be multiplied or divided by merely adding or subtracting the corresponding terms of the arithmetical progression; thus the product of four and eight may be found by taking the sum of the corresponding terms in the arithmetical progression, viz. 2 and 3, for their sum 5 points out 32 as the product of 4 and 8. The numbers 0, 1, 2, 3, &c. are therefore the logarithms of 1, 2, 4, 8, &c. The choice of the two progressions being altogether arbitrary, Baron Napier took the arithmetical progression which we have given above, and made the term 0 correspond with the unit of the geometrical progression, which he regulated in such a manner that when its terms are represented by the abscissæ of an equilateral hyperbola in which the first absciss and the first ordinate are each equal to 1, the logarithms are represented by the hyperbolic spaces. In consequence, however, of the inconvenience of this geometrical progression, Baron Napier, after consulting upon the subject with Henry Briggs of Gresham College, substituted the decuple progression, 1, 10, 100, 1000, of which 0, 1, 2, 3, 4, &c. are the logarithms. Nothing now remained but to construct tables of logarithms, by finding the logarithms of the intermediate numbers between the terms of the decuple progression. Napier, however, died before he was able to calculate these tables; but his loss was in some measure supplied by Mr Briggs, who applied himself with zeal to this arduous task, and published in 1618 a table of the logarithms of all numbers from 1 to 1000. In 1624 he published another table containing the logarithms from 1000 to 20,000, and from 90,000 to 100,000. The defects in Briggs's tables were filled up by his friends Gellibrand and Hadrian Vlacq, who also published new tables containing the logarithms of sines, tangents, &c. for 90 degrees.

Tables of logarithms computed by Mr Briggs.

A.D. 1618.

Discoveries of Harriot. Born 1560. Died 1621.

28. During the time when Napier and Briggs were doing honour to their country by completing the system of logarithms, algebra was making great progress in the hands of our countryman Harriot. His *Artis analyticæ Praxis*, which appeared in 1620, contains, along with the discoveries of its author, a complete view of the state of algebra. He simplified the notation by substituting small letters instead of the capitals introduced by Vieta; and he was the first who showed that every equation beyond the first degree may be considered as produced by the multiplication of as many simple equations as there are units in the exponent of the highest power of the unknown quantity. From this he deduced the relation which exists between the roots of an equation, and the coefficients of the terms of which it consists.

Fernel first gives the measure of the earth.

29. About the same time, a foreign author named Fernel, physician to King Henry II. of France, had the merit of being the first who gave the measure of the earth. By reckoning the number of turns made by a coach-wheel from Amiens to Paris, till the altitude of the pole star was increased one degree, he estimated the length of a degree of the meridian to be 56,746 toises, which is wonderfully near the truth. He also wrote a work on mathematics, entitled *De Proportionibus.*—About this time it was shown by Peter Metius, a German mathematician, that if the diameter of a circle be 113, its circumference will be 355. This result, so very near the truth, and expressed in so few figures, has preserved the name of its author.

Metius finds more correct numbers for the diameter and circumference of a circle.

Discoveries of Descartes in algebra. born 1596. Died 1650.

30. The next author, whose labours claim our attention, is the illustrious Descartes. We do not allude to those wild and ingenious speculations by which this philosopher endeavoured to explain the celestial phenomena; but to these great discoveries with which he enriched the kindred sciences of algebra and geometry. He introduced the present method of marking the powers of any quantity by numerical exponents. He first explained the use of negative roots in equations, and showed that they are as real and useful as positive roots, the only difference between them being founded on the different manner in which the corresponding quantities are considered. He pointed out the method of finding the number of positive and negative roots in any equation where the roots are real; and developed the method of indeterminates which Vieta had obscurely hinted at.

He extends the application of algebra to geometry.

31. Though Regiomontanus, Tartalea, and Bombelli, had resolved several geometrical problems by means of algebra, yet the general method of applying geometry to algebra was first given by Vieta. It is to Descartes, however, that we are indebted for the beautiful and extensive use which he made of his discovery. His method of representing the nature of curve lines by equations, and of arranging them in different orders according to the equations which distinguished them, opened a vast field of inquiry to subsequent mathematicians; and his methods of constructing curves of double curvature, and of drawing tangents to curve lines, have contributed much to the progress of geometry. The inverse method of tangents, which it was reserved for the fluxionary calculus to bring to perfection, originated at this time in a problem which Florimundus de Beaune proposed to Descartes. It was required to construct a curve in which the ratio of the ordinate and subtangent should be the same as that of a given line to the portion of the ordinate included between the curve and a line inclined at a given angle. The curve was constructed by Descartes, and several of its properties detected, but he was unable to accomplish the complete solution of the problem. These discoveries of Descartes were studied and improved by his successors, among whom

A. D. 1647.

A. D. 1658.

whom we may number the celebrated Hudde, who published in Schooten's commentary on the geometry of Descartes, an excellent method of determining if an equation of any order contains several equal roots, and of discovering the roots which it contains.

Discoveries of Pascal. Born 1623. Died 1662.

32. The celebrated Pascal, who was equally distinguished by his literary and his scientific acquirements, extended the boundaries of analysis by the invention of his arithmetical triangle. By means of arbitrary numbers placed at the vertex of the triangle, he forms all the figurate numbers in succession, and determines the ratio between the numbers of any two cases, and the various sums resulting from the addition of all the numbers of one rank taken in any possible direction. This ingenious invention gave rise to the calculation of probabilities in the theory of games of chance, and formed the foundation of an excellent treatise of Huygens, entitled *De Ratiociniis in Ludo Aleæ*, published in 1657.

Discoveries of Fermat. Born 1590. Died 1663.

33. Several curious properties of numbers were at the same time discovered by Fermat at Toulouse. In the theory of prime numbers, particularly, which had first been considered by Eratosthenes, Fermat made great discoveries; and in the doctrine of indeterminate problems, he seems to have been deeply versed, having republished the arithmetic of Diophantus, and enriched it with many valuable notes of his own. He invented the method of discovering the *maxima* and *minima* of variable quantities, which serves to determine the tangents of geometrical curves, and paved the way for the invention of the fluxionary calculus.

Cavaleri's method of indivisibles. 1635.

34. Another step towards the discovery of fluxions was at this time made by Cavaleri in his geometry of indivisibles. In this work, which was published in 1635, its author supposes every plane surface to consist of an infinite number of planes; and he lays it down as an axiom, that these infinite sums of lines and surfaces have the same ratio when compared with the unit in each case as the superficies and solids to be measured. This ingenious method was employed by Cavaleri in the quadrature of the conic sections, and in the curvature of solids generated by their revolution; and in order to prove the accuracy of his theory, he deduced the same results from different principles.

The same subject discussed by Roberval. 1634.

35. Problems of a similar kind had been solved by Fermat and Descartes, and now occupied the attention of Roberval. The latter of these mathematicians began his investigation of this subject about a year before the publication of Cavaleri's work, and the methods which both of them employed were so far the same as to be founded on the principles of indivisibles. In the mode, however, which Roberval adopted, planes and solids were considered as composed of an infinite number of rectangles, whose altitudes and the thickness of their sections were infinitely small.—By means of this method, Roberval determined the area of the cycloid, the centre of gravity of this area, and the solids formed by its revolution on its axis and base. He also invented a general method for tangents, similar in metaphysical principles to that of fluxions, and applicable both to mechanical and geometrical curves. By means of this, he determined the tangents of the cycloid; but there were some curves which resisted its application. Considering every curve to be generated by the motion of a point, Roberval regarded this point as acted upon at every instant with two velocities ascertained from the nature of the curve. He constructed a parallelogram having its sides in the same ratio as the two velocities; and he assumes as a principle, that the direction of the tangent must fall on the diagonal, the position of which being ascertained, gives the position of the tangent.

Labours of Torricelli. 1644.

36. In 1644, solutions of the cycloidal problems formerly resolved by Roberval were published by Torricelli as invented by himself. The demonstrations of Roberval had been transmitted to Galileo the preceptor of Torricelli, and had also been published in 1637 in Mersennus's Universal Harmony. The Italian philosopher was consequently accused of plagiarism by Roberval, and the charge so deeply affected his mind as to bring him prematurely to the grave. It is obvious, however, from the demonstrations of Torricelli, that he had never seen those of Roberval, and that he was far from meriting that cruel accusation which deprived science of one of its brightest ornaments.

Farther discoveries of Pascal. 1658.

37. The cycloid having attracted the notice of geometers from the number and singularity of its properties, the celebrated Pascal proposed to them a variety of new problems relative to this curve, and offered prizes for their solution. These problems required the area of any cycloidal segment, the centre of gravity of that segment, the solids, and the centres of gravity of the solids, which are generated either by a whole revolution, a half or a quarter of a revolution of this segment round an abscissa or an ordinate. The resolution of these problems was attempted by Huygens, Sluze, Sir Christopher Wren, Fermat, and Roberval. Sluze discovered an ingenious method of finding the area of the curve. Huygens squared the segment comprised between the vertex, and as far as a fourth of the diameter of the generating circle; and Sir Christopher Wren ascertained the length of the cycloidal arc included between the vertex and the ordinate, the centre of gravity of this arc, and the surfaces of the solids generated during its revolution. These attempts were not considered by their authors as solutions of Pascal's problems, and therefore they did not lay claim to his prize. Our countryman Wallis, however, and Lallouere a Jesuit, gave in a solution of all the problems, and thought themselves entitled to the proffered reward. In the methods employed by these mathematicians, Pascal detected several sources of error; and it was reserved for that great genius to furnish a complete solution of his own problems. Extending his investigations to curtate and prolate cycloids, he proved that the length of these curves depends on the rectification of the ellipse, and assigned in each case the axis of the ellipse. From this method he deduced this curious theorem, that if two cycloids, the one curtate and the other prolate, be such, that the base of the one is equal to the circumference of the circle by which the other is generated, the length of these two cycloids will be equal.

Labours of Wallis. 1655.

38. While these discoveries were making on the continent, the friends of science in Britain were actively employed in promoting its advancement. In 1655, Wallis published his *Arithmetica Infinitorum*, a work of great genius. He attempted to determine by the summation of infinite series, the quadrature of curves, and the curvature of solids, subjects which were afterwards 1682.
investigated in a different manner by Ishmael Bullialdus. By Wallis's method, curves were squared when their ordinates are expressed by one term, and when their

their ordinates were complex quantities raised to entire and positive powers, these ordinates were resolved into series, of which each term is a monomial. Wallis attempted to extend his theory to curves whose ordinates were complex and radical, by attempting to interpolate the series of the former kind with a new series; but he was unsuccessful.

Discoveries of Newton.

39. It was left to Newton to remove this difficulty. He solved the problem in a more direct and simple manner by the aid of his new formula for expanding into an infinite series any power of a binomial, whether its exponent was positive or negative, an integer or a fraction. Algebra is also indebted to this illustrious mathematician for a simple and extensive method of resolving an equation into commensurable factors; for a method of summing up the powers of the roots of an equation, of extracting the roots of quantities partly commensurable, and partly incommensurable, and of finding by approximation the roots of literal and numerical equations of all orders.

Lord Brouncker discovers continued fractions. Born 1620. Died 1684.

40. About this time, William Lord Brouncker, in attempting to demonstrate an expression of Wallis on the magnitude of the circle, discovered the theory of continued fractions. When an irreducible fraction is expressed by numbers too great and complicated to be easily employed by the analyst, the method of Lord Brouncker enables us to substitute an expression much more simple and nearly equivalent. This theory, which enables us to find a very accurate relation between the diameter and circumference of the circle, was employed by Huygens * in the calculation of his planetary automaton, for representing the motions of the solar system, and was enlarged and improved by other celebrated geometers. Lord Brouncker had likewise the merit of discovering an infinite series to represent the area of the hyperbola. The same discovery was made by Nicholas Mercator, who published it in his *Logarithmotechnia* in 1668.

* *Opera Posthuma*, tom. ii. *sub finem.*

Labours of James Gregory.

41. The subject of infinite series received considerable addition from Mr James Gregory. He was the first who gave the tangent and secant in terms of the arc, and, inversely, the arc in terms of the tangent and secant. He constructed series for finding directly the logarithm of the tangent and secant from the value of the arc, and the logarithm of the arc from that of the tangent and secant; and he applied this theory of infinite series to the rectification of the ellipsis and hyperbola.

Labours of Dr Barrow.

42. The differential triangle invented by the learned Dr Barrow, for drawing tangents to curves, may be regarded as another contribution towards the invention of fluxions. This triangle has for its sides the element of the curve and those of the absciss and ordinate, and those sides are treated as quantities infinitely small.

Theory of evolutes discovered by Huygens, 1673.

43. The doctrine of evolutes had been slightly touched upon by Apollonius. It remained, however, for the illustrious Huygens to bring it to perfection. His theory of evolutes is contained in his *Horologium Oscillatorium*, published in 1673, and may be regarded as one of the finest discoveries in geometry. When any curve is given, Huygens has pointed out the method of constructing a second curve, by drawing a series of perpendiculars to the first, which are tangents to the second; and of finding the first curve from the second. From this principle he deduces several theorems on the rectification of curves; and that remarkable property of the cycloid, in which an equal and similar cycloid is produced by evolution.

History of the discovery of fluxions.

44. In contemplating the progress of analysis from the beginning of the 17th century, to the invention of fluxions, we cannot fail to perceive the principles of that calculus gradually unfolding themselves to view. The human mind seemed to advance with rapidity towards that great discovery; and it is by no means unlikely that it would soon have arrived at the doctrine of fluxions, even if the superior genius of Newton had not accelerated its progress. In Cavalerius's *Geometria Indivisibilium*, we perceive the germ of the infinitesimal calculus; and the method of Roberval for finding the tangents of curves, bears a striking analogy to the metaphysics of the fluxionary calculus. It was the glory of Newton, however, to invent and illustrate the method of fluxions; and the obscure hints which he received from preceding mathematicians, do not in the least detract from the merit of our illustrious countryman.

General remarks on the dispute between Newton and Leibnitz.

45. On the claims of Leibnitz as a second inventor of fluxions, and the illiberal violence with which they have been urged by foreign mathematicians, we would wish to speak with delicacy and moderation. Who that can appreciate the discoveries of that celebrated mathematician, or is acquainted with that penetrating genius which threw light on every department of human knowledge, would willingly stain his memory with an ungracious imputation? The accusation of plagiarism is one of those charges which it is difficult either to substantiate or repel, and when directed against a great man, ought never, without the clearest evidence, to be wantonly preferred or willingly received. If charitable sentiments are ever to be entertained towards others,—to what class of beings should they be more cheerfully extended than to those who have been the ornaments of human nature? If society has agreed to regard as sacred the failings and excentricities of genius,—when ought that reverence to be more strongly excited than when we are passing judgment on its mightiest efforts? Inquiries into the motives and actions of the learned ought never to be wantonly indulged. When the honour of our country, or the character of an individual, requires such an investigation, a regard to truth, and a contempt of national prejudice, should guide the inquiry.—We should proceed with delicacy and forbearance.—We should tread lightly even on the ashes of genius. It is not uncommon to witness the indulgence of malicious pleasure, in detracting from the merits of a distinguished character. The assailant raises himself for a while to the level of his enemy, and acquires glory by his fall. But let him remember that the laurels thus won cannot flourish long. The same public opinion which conferred them will tear them from his brow, and consign the accuser to that infamy from which the brightest abilities will be insufficient to raise him. The consequences of such conduct have been seen in the fall of Torricelli. It was the charges of plagiarism, preferred by Roberval, that hurried this young and accomplished philosopher to an early grave.

46. We have been led into these observations by studying the dispute between the followers of Newton and Leibnitz. The claims of the British, as well as those of the

the foreign mathematicians, have undoubtedly been too high; and victory rather than truth seems to have been the object of contest. Even the name of Newton has not escaped from serious imputations. The immensity of the stake for which the different parties contended, may perhaps justify the commencement of the dispute; and the brilliancy of the talents that were called into action, may leave us no cause to regret its continuance: But nothing can reconcile us to those personal animosities in which the good sense and temper of philosophy are lost, and that violence of literary warfare where science can gain nothing in the combat.—In giving an account, therefore, of that interesting dispute, we shall merely give a brief view of the facts that relate to the discovery of the higher calculus, and make a few observations on the conclusions to which they lead.

Newton publishes a tract containing the principles of fluxions.

47. In the year 1669, a paper of Sir Isaac Newton's, entitled *De analysi per equationes numero terminorum infinitas*, was communicated by Dr Barrow to Mr Collins, one of the secretaries of the Royal Society. In this paper the author points out a new method of squaring curves, both when the expression of the ordinate is a rational quantity, and when it contains complex radicals, by evolving the expression of the ordinate into an infinite number of simple terms by means of the binomial theorem. In a letter from Newton to Collins, dated December 10. 1672, there is contained a method of drawing tangents to curve lines, without being obstructed by radicals; and in both these works, an account of which was circulated on the continent by the secretaries of the Royal Society, the principles of the fluxional calculus are plainly exhibited; and it is the opinion of all the disputants, that those works at least prove, that Newton must have been acquainted with the method of fluxions when he composed them.

48. Leibnitz came to London in 1673, and though there is no direct evidence that he saw Newton's paper *De Analysi per Equationes*, &c. yet it is certain that he had seen Sir Isaac's letter to Collins of 1672; and it is highly improbable that such a man as Leibnitz should have been ignorant of a paper of Newton's which had been four years in the possession of the public, and which contained discussions at that time interesting to every mathematician.

Correspondence between Leibnitz and Oldenburg.

49. A letter from Newton to Oldenburg, one of the secretaries of the Royal Society, dated October 24. 1676, was communicated to Leibnitz. This letter contains several theorems without the demonstrations, which are founded on the method of fluxions, and merely states that they result from the solution of a general problem. The enunciation of this problem he expresses in a cypher, the meaning of which was, An equation containing any number of flowing quantities being given, to find the fluxions, and inversely. In reply to this communication, Leibnitz transmitted a letter to Oldenburg, dated June 21. 1677, where he explains the nature of the differential calculus, and affirms, that he had long employed it for drawing tangents to curve lines.

Leibnitz publishes an account of the differential calculus.

50. The correspondence between Leibnitz and Oldenburg having been broken off by the death of the latter, Leibnitz published in the *Acta Erudit. Lips.* for October 1684, the principles of the new analysis, under the title of *Nova Methodus pro maximis et minimis, itemque tangentibus, quæ nec fractas, nec irrationales quantitates moratur, et singulare pro illis calculus.* This paper contains the method of differencing simple, fractional, and radical quantities, and the application of the calculus to the solution of some physical and geometrical problems. In 1685, he likewise published two small pamphlets on the quadrature of curves, containing the principles of the *Calculus Summatorius*, or the *Inverse Method of Fluxions;* and in 1686 there appeared another tract by the same author, *On the Recondite Geometry, and the Analysis of Indivisibles and Infinites*, containing the fundamental rule of the integral calculus.

Newton publishes his Principia.

51. Towards the close of the year 1686, Sir Isaac Newton gave to the world his illustrious work entitled *Philosophiæ Naturalis Principia Mathematica.* Some of the most difficult problems in this work are founded on the fluxional calculus; and it is allowed by Bossut, one of the defenders of Leibnitz, "that mathematicians did Newton the justice to acknowledge, that at the period when his *Principia* was published, he was master of the method of fluxions to a high degree, at least with respect to that part which concerns the quadrature of curves." The claim of Leibnitz, as a separate inventor of the differential calculus, is evidently allowed by Newton himself, when he observes, that Leibnitz had communicated to him a method similar to his own for drawing tangents, &c. and differing from it only in the enunciation and notation.

Leibnitz proposes the problem of the isochronous curve; which is solved by Huygens in 1687.

52. About this time, it became fashionable among geometers to perplex each other by the proposal of new and difficult problems, a practice which powerfully contributed to the progress of mathematics. The dispute in which Leibnitz was engaged with the Cartesians respecting the measure of active forces, which the former supposed to be as the simple velocity, while the latter asserted, that they were as the square of the velocity, led him to propose the problem of the isochronous curve, or "to find the curve which a heavy body must describe equally, in order to approach or recede from a horizontal plane in equal times." This curve was found by Huygens to be the second cubic parabola; but he gave only its properties and construction without the demonstrations. The same solution, along with the demonstration, was given by Leibnitz in 1689, who, at the same time, proposed to geometers to find the *paracentric isochronal curve*, or the curve in which a body would equally approach or recede from a given point in equal times.

James Bernouilli also finds the isochronous curve.

53. It was at this time that the two brothers, James and John Bernouilli, began to display those talents from which the physical and mathematical sciences received such immense improvements. James was born in 1654, and died in 1705; and John, who was his pupil, was born in 1667, and lived to the advanced age of 68 years. In 1690, James Bernouilli gave the same solution of the isochronous curve that had been given by Huygens and Leibnitz; and proposed the celebrated problem of the catenary curve, which had formerly perplexed the ingenuity of Galileo. In two memoirs, published in 1691, he determined, by means of the inverse method of fluxions, the tangents of the parabolic spiral, the logarithmic spiral, and the loxedromic curve, and likewise the quadratures of their areas.

1691. Solution of the problem of the catenarian curve, and other analogous problems.

54. The problem of the catenary curve having occupied the attention of geometers, was resolved by Huygens, Leibnitz,

Leibnitz, and John Bernouilli. In these solutions, however, the gravity of the catenary curve was supposed to be uniform; but James Bernouilli extended the solution to cases where the weight of the curve varies from one point to another, according to a given law. From this problem he was also conducted to the determination of the curvature of a bended bow, and that of an elastic bar fixed at one extremity, and loaded at the other with a given weight. In the hopes of contributing to the progress of navigation, the same mathematician considered the form of a sail swoln with the wind. When the wind, after striking the sail, is not prevented from escaping, the curvature of the sail is that of the common catenarian curve; but when the sail is supposed perfectly flexible, and filled with a fluid pressing downwards on itself, as water presses on the sides of a vessel, the curve which it forms is one of those denominated *lintcariæ*, which is expressed by the same equation as the common elastic curve, where the extensions are reckoned proportional to the forces applied at each point. —The same problem was solved in the *Journal des Sçavans* for 1692, by John Bernouilli; but there is satisfactory evidence that it was chiefly borrowed from his brother James.

Labours of James Bernouilli. 1692.

55. The attention of James Bernouilli was now directed to the theory of curves produced by the revolution of one curve upon another. He considers one curve rolling upon a given curve, equal to the first, and immoveable. He determines the evolute and the caustic of the epicycloid, described by a point of the moving circle, and he deduces from it other two curves, denominated the *antievolute* and *pericaustic*. He found also that the logarithmic spiral was its own evolute, caustic, antievolute, and pericaustic; and that an analogous property belonged to the cycloid.

1692. Problem of Viviani solved.

56. About this time Viviani, an Italian geometer, distinguished as the restorer of Aristeus's conic sections, required the solution of the following problem, that there existed a temple of a hemispherical form, pierced with four equal windows, with such skill that the remainder of the hemisphere might be perfectly squared. With the aid of the new analysis, Leibnitz and James Bernouilli immediately found a solution, while that of Viviani was founded on the ancient geometry. He proved that the problem might be solved, by placing, parallel to the base of the hemisphere, two right cylinders, the axes of which should pass through the centres of two radii, forming a diameter of the circle of the base, and piercing the dome each way.

Tschirnhausen on caustic curves.

57. Prior to some of these discussions, the curves called *caustic*, and sometimes *Tschirnhausenian*, were discovered by Tschirnhausen. These curves are formed by the crossing of the rays of light, when reflected from a curved surface, or refracted through a lens so as not to meet in a single point. With the assistance of the common geometry, Tschirnhausen discovered that they are equal to straight lines when they are formed by geometrical curves, and found out several other curious properties. By the aid of the higher calculus, James Bernouilli extended these researches, and added greatly to the theory of caustics produced by refraction.

James Bernouilli attends to the same subject, 1693.

and solves the problem of the paracentric isochronal curve,

58. The problem of the paracentric isochronal curve, proposed by Leibnitz in 1689, was solved by James Bernouilli, who took for ordinates parallel straight lines, and for abscissas the chords of an infinite number of concentric circles described about the given point. In this way he obtained a separate equation, constructed at first by the rectification of the elastic curve, and afterwards by the rectification of an algebraic curve. The same problem was solved by John Bernouilli and Leibnitz. 1689.

The exponential calculus invented by Leibnitz and John Bernouilli.

59. In 1694, a branch of the new analysis, called the *exponential calculus*, was invented separately by John Bernouilli and Leibnitz. It consists in differencing and integrating exponential quantities or powers with variable exponents. To Leibnitz, the priority in point of invention certainly belongs; but John Bernouilli was the first who published the rules and uses of the calculus.

The Marquis l'Hospital publishes his analysis of infinites.

60. The marquis l'Hospital, who, in 1695, had solved the problem about the curve of equilibration in draw-bridges, and shewn it to be an epicycloid, published in the following year his *Analysis of Infinites for the understanding of curve lines.* In this celebrated work, the differential calculus, or the direct method of fluxions, was fully explained and illustrated; and as the knowledge of the higher geometry had been hitherto confined to a few, it was now destined to enlighten the different nations of Europe.

Newton finds the solid of least resistance.

61. The methods which were employed by Descartes, Fermat, &c. for finding the maxima and minima of quantities, yielded in point of simplicity and generality to that which was derived from the doctrine of fluxions. Another class of problems, however, of the same kind, but more complicated, from their requiring the inverse method of fluxions, began now to exercise the ingenuity of mathematicians. A problem of this class for finding the solid of least resistance, was solved by Newton in the 34th proposition of the 2d book of his *Principia*. After having determined the truncated right cone, which being moved in a fluid by the smallest base (which is unknown,) experiences the least resistance, he gave without any demonstration the ratio from which might be derived the differential equation of the curve that generates by a revolution of its axis the solid of least resistance. A general solution, however, was still wanting, till the attention of geometers was directed to the subject by John Bernouilli, who proposed, in 1697, the celebrated problem of the *Brachystochronon*, or the curve along the concave side of which if a heavy body descend, it will pass in the least time possible from one point to another, the two points not being in the same vertical line. This problem was resolved by Leibnitz, Newton, the marquis de l'Hospital, and James Bernouilli, who demonstrated that the curve of quickest descent is a cycloid reversed. This result will appear at first surprising, when we consider a line to be the shortest distance between two points; but the surprise will cease when we reflect, that in a concave curve lying between the two given points the moving body descends at first in a more vertical direction, and therefore acquires a greater velocity than when it rolls down an inclined plane. This addition to its velocity, consequently, at the commencement of its path may balance the increase of space through which it has to move.

Dispute between James and John Bernouilli on isoperimetrical figures.

62. At the close of this discussion, commenced that celebrated dispute about isoperimetrical problems, between James and John Bernouilli, in which the qualities of the head were more conspicuous than those of the heart.

heart. These illustrious characters, connected by the strongest ties of affinity, were, at the commencement of their distinguished career, united by the warmest affection. John was initiated by his elder brother into the mathematical sciences; and a generous emulation, softened by friendship in the one, and gratitude in the other, continued for some years to direct their studies, and accelerate their progress. There are few men, however, who can support at the same time the character of a rival and a friend. The success of the one party is apt to awaken the envy of the other, and success itself is often the parent of presumption. A foundation is thus laid for future dissension; and it is a melancholy fact in the history of learning, that the most ardent friendships have been sacrificed on the altar of literary ambition. Such was the case between the two
1695. Bernouillis. As soon as John was settled as professor of mathematics at Groningen, all friendly intercourse between the two brothers was at an end. Regarding John as the aggressor, and provoked at the ingratitude which he exhibited, his brother James challenged him
Problems proposed by James to John Bernouilli. by name to solve the following problems: 1. "To find, among all the isoperimetrical curves between given limits, such a curve, that, constructing a second curve, the ordinates of which shall be the functions of the ordinates or arcs of the former, the area of the second curve shall be a maximum or a minimum.—2. "To find among all the cycloids which a heavy body may describe in its descent from a point to a line, the position of which is given, that cycloid which is described in the least possible time."—A prize of 50 florins was promised to John Bernouilli, if, within three months, he engaged to solve these problems, and publish within a year legitimate solutions of them.

63. In a short time John Bernouilli produced his solution and demanded the prize. He succeeded in constructing the problem of swiftest descent; but his solution of the other problem was radically defective. This failure mortified that vanity with which he gloried in his apparent success. He acknowledged the mistake in his solution, and, with the same imperious tone, transmitted a new result, and redemanded the prize. This new solution, which was still defective, drew down the wit and ridicule of James Bernouilli, which his brother attempted to repel by a torrent of coarse invective.

1700. 64. Leibnitz, Newton, and the marquis l'Hospital, being appointed arbiters in this dispute, James Bernouilli published, in 1700, the formulæ of the isoperimetrical problem, without any demonstration; and John transmitted his solution to the French academy in February 1701, on condition that it should not be opened till his brother's demonstrations were published. In consequence of this, James Bernouilli published his solution in May 1701, in the *Acta Eruditorum*, under the following title, *Analysis magni Problematis Isoperimetrici*, and gained great honour from the skill which it displayed. For five years John Bernouilli was silent upon the subject; but his brother dying in 1705, he published his solution in the Memoirs of the Academy for 1706. About 13 years afterwards, John Bernouilli having perceived the source of his error, confessed his mistake, and published a new solution, not very different from that of his brother, in the Memoirs of the Academy for 1718.

65. In the problem relative to the cycloid of swiftest descent, John Bernouilli obtained a result similar to that of his brother, by a very ingenious method, which extended the bounds of the new analysis. In his investigations he employed the synchronous curve, or that which cuts a series of similar curves placed in similar positions, so that the arcs of the latter included between a given point and the synchronous curve, shall be described by a heavy body in equal times. He demonstrated, that of all the cycloids thus intersected, that which is cut perpendicularly is described in less time than any other terminating equally at the synchronous curve. But being unable to give a general solution of the problem, he applied to Leibnitz, who easily resolved it, and at that time invented the method of differencing *de curva in curvam*. John Bernouilli's solution of the second problem. 1704.

66. About a month after the death of the marquis de l'Hospital, John Bernouilli declared himself the author of a rule given by the marquis in his Analysis of Infinites, for finding the value of a fraction, whose numerator and denominator should vanish at the same instant, when the variable quantity that enters into it has a certain given value. The defence made by the marquis's friends only induced John Bernouilli to make greater demands, till he claimed as his own the most important parts of the Analysis of Infinites: But it does not appear, from an examination of the subject, that there is any foundation for his claims.

67. Towards the close of 1704, Sir Isaac Newton published, at the end of his Optics, his *Enumeratio linearum tertiæ ordinis*, and his treatise *De Quadratura Curvarum*. The first of these papers displays great ability; but is founded only on the common algebra, and the doctrine of series which Newton had brought to such perfection. His treatise, *De Quadratura Curvarum*, contains the resolution of fluxional formulæ, with one variable quantity which leads to the quadrature of curves. By means of certain series he obtains the resolution of several complicated formulæ, by referring them to such as are more simple; and these series being interrupted in particular cases, give the fluents in finite terms. From this several interesting propositions are deduced, among which is the method of resolving rational fractions. In 1711 Newton published his *Method of Fluxions*. The object of this work is to determine, by simple algebra, the linear coefficients of an equation that satisfies as many conditions as there are coefficients, and to construct a curve of the parabolic kind passing through any number of given points. Hence arises a simple method of finding the approximate quadrature of curves, in which a certain number of ordinates are determinable. It has been the opinion of some able mathematicians, that this treatise contains the first principles of the integral calculus with finite differences, afterwards invented by Dr Taylor. A posthumous work of Newton's, entitled *The Method of Fluxions, and of Infinite Series*, was published by Dr Pemberton about nine years after the death of its author; but it does not contain any new investigations which accelerated the progress of the new analysis. Labours of Newton. 1704. 1711. 1736.

68. The mathematical sciences were at this time indebted to the labours of Manfredi, Parent, and Saurin. The former of these geometers published a very able work, *De Constructione Equationum differentialium primi gradus*. To Parent we are indebted for the problem Labours of Manfredi, Parent, and Saurin, 1707.

by

by which we obtain the ratio between the velocity of the power and the weight, for finding the *maximum* effect of machines; but his reputation was much injured by the obscurity of his writings. Saurin was celebrated for his theoretical and practical knowledge of watchmaking, and was the first who elucidated the theory of tangents to the multiple points of curves.

Account of the dispute between Newton and Leibnitz.

69. While the science of analysis was thus advancing with rapidity, the dispute between Newton and Leibnitz began to be agitated among the mathematicians of Europe. These illustrious rivals seemed to have been hitherto contented with sharing the honour of having invented the fluxional calculus. But as soon as the priority of invention was attributed to Newton, the friends of Leibnitz came forward with eagerness to support the claims of their master.

Facio de Duillier commences the dispute in favour of Newton.

70. In a small work on the curve of swiftest descent, and the solid of least resistance, published in 1699, Nicholas Facio de Duillier, an eminent Genoese, attributed to Newton the first invention of Fluxions, and hinted, that Leibnitz, as the second inventor, had borrowed from the English philosopher. Exasperated at this improper insinuation, Leibnitz came forward in his own defence, and appeals to the admission of Newton in his *Principia*, that neither had borrowed from the other. He expressed his conviction, that Facio de Duillier was not authorised by Sir Isaac, to prefer such a charge, and threw himself upon the testimony and candour of the English geometer.

Leibnitz defends himself.

Dr Keill makes the samecharge against Leibnitz. 1708.

71. The discussion rested in this situation for several years, till our celebrated countryman, Dr Keill, instigated by an attack upon Newton in the Leipsic Journal, repeated the same charge against Leibnitz. The German philosopher made the same reply as he did to his former opponent, and treated Dr Keill as a young man incapable of judging upon the subject. In 1711, Dr Keill addressed a letter to Sir Hans Sloane, secretary to the Royal Society, and accused Leibnitz of having adopted the differential notation, in order to have it believed that he did not borrow his calculus from the writings of Newton.

1711.

Leibnitz appeals to the Royal Society.

72. Leibnitz was with reason irritated at this accusation, and called upon the Royal Society to interfere in his behalf. A committee of that learned body was accordingly appointed to investigate the subject, and their report was published in 1712, under the title of *Commercium Epistolicum de Analysi promota*. In this report the committee maintain that Leibnitz was not the first inventor, and absolve Dr Keill from all blame in giving the priority of invention to Newton. They were cautious, however, in stating their opinion upon that part of the charge in which Leibnitz was accused of plagiarism.

1712.

Who appoint a committee to examine and report.

John Bernouilli replies to their report given in the *Commercium Epistolicum*.

73. In answer to the arguments advanced in the *Commercium Epistolicum*, John Bernouilli, the particular friend of Leibnitz, published a letter, in which he has the assurance to state, that the method of fluxions did not precede the differential calculus, but that it might have taken its rise from it. The reason which he assigns for this strange assertion is, that the differential calculus was published before Newton had introduced an uniform algorithm into the method of fluxions. But it may as well be maintained that Newton did not discover the theory of universal gravitation, because the attractive force of mountains and of smaller portions of matter was not ascertained till the time of Maskelyne and Cavendish. The principles of fluxions are allowed to have been discovered before those of the differential calculus, and yet the former originated from the latter, because the fluxional notation was not given at the same time!

Remarks on the controversy.

74. Notwithstanding the ridiculous assertion of John Bernouilli, it has been admitted by all the foreign mathematicians that Newton was the first inventor of the method of fluxions. The point at issue therefore is merely this:—did Leibnitz see any of the writings of Newton that contained the principles of fluxions before he published in 1684 his *Nova Methodus pro maximis et minimis*? The friends of Leibnitz have adduced some presumptive proofs that he had never seen the treatise of Newton *de Analysi*, nor the letter to Collins, in both of which the principles of the new calculus were to be found; and in order to strengthen their argument, they have not scrupled to assert, that the writings already mentioned contained but a vague and obscure indication of the method of fluxions, and that Leibnitz might have perused them without having discovered it. This subsidiary argument, however, rests upon the opinion of individuals; and the only way of repelling it is to give the opinion of an impartial judge. M. Montucla, the celebrated historian of the mathematics, who being a Frenchman, cannot be suspected of partiality to the English, has admitted that Newton in his treatise *de Analysi* "has disclosed in a very concise and obscure manner his principles of fluxions," and "that the suspicion of Leibnitz having seen this work is not destitute of probability, for Leibnitz admitted, that in his interview with Collins he had seen a part of the epistolary correspondence between Newton and that gentleman." It is evident therefore that Leibnitz had opportunities of being acquainted with the doctrine of fluxions, before he had thought of the differential calculus; and as he was in London, where Newton's treatise was published, and in company with the very men to whom the new analysis had been communicated, it is very likely that he then acquired some knowledge of the subject. In favour of Leibnitz, however, it is but justice to say, that the transition from the method of tangents by Dr Barrow to the differential calculus is so simple, that Leibnitz might very easily have perceived it; and that the notation of his analysis, the numerous applications which he made of it, and the perfection to which he carried the integral calculus, are considerable proofs that he was innocent of the charge which the English have attempted to fix upon his memory.

Works on the doctrine of chance. 1708.

75. In 1708, Remond de Montmort published a curious work, entitled the Analysis of Games of Chance, in which the common algebra was applied to the computation of probabilities, and the estimation of chances. Though this work did not contain any great discovery, yet it gave extent to the theory of series, and admirably illustrated the doctrine of combinations. The same subject was afterwards discussed by M. de Moivre, a French protestant residing in England, in a small treatise entitled *Mensura Sortis*, in which are given the elements of the theory of recurrent series, and some very ingenious applications of it. Another edition was published in English in 1738, under the title of the *Doctrine of Chances*.

1711.

Leibnitz proposes to the English the problem of orthogonal trajectories.

76. A short time before his death, Leibnitz proposed to the English geometers the celebrated problem of orthogonal trajectories, which was to find the curve that cuts a series of given curves at a constant angle, or at an angle varying according to a given law. This problem was put into the hands of Sir Isaac Newton when he returned to dinner greatly fatigued, and he brought it to an equation before he went to rest. Leibnitz being recently dead, John Bernouilli assumed his place, and maintained, that nothing was easier than to bring the problem to an equation, and that the solution of the problem was not complete till the differential equation of the trajectory was resolved. Nicholas Bernouilli, the son of John, resolved the particular case in which the intersected curves are hyperbolas with the same centre and the same vertex. James Hermann and Nicholas Bernouilli, the nephew of John, treated the subject by more general methods, which applied to the cases in which the intersected curves were geometrical. The most complete solution, however, was given by Dr
1717. Taylor in the Philosophical Transactions for 1717, though it was not sufficiently general, and could not apply to some cases capable of resolution. This defect was supplied by John Bernouilli, who in the Leipsic
1718. Transactions for 1718, published a very simple solution, embracing all the geometrical curves, and a great number of the mechanical ones.

Integration of rational fractions. 1719.

77. During these discussions, several difficult problems on the integration of rational fractions were proposed by Dr Taylor, and solved by John Bernouilli. This subject, however, had been first discussed by Roger Cotes, professor of mathematics at Cambridge, who died in 1710. In his posthumous work entitled *Harmonia Mensurarum*, published in 1716, he gave general and convenient formulæ for the integration of rational fractions; and we are indebted to this young geometer for his method of estimating errors in mixed mathematics, for his remarks on the differential method of Newton, and for his celebrated theorem for resolving certain equations.

Labours of Roger Cotes, born 1676.

Dr Taylor invents the integral calculus of finite differences.

78. In 1715, Dr Taylor published his learned work entitled *Methodus incrementorum directa et inversa.* In this work the doctor gives the name of increments or decrements of variable quantities to the differences, whether finite or infinitely small, of two consecutive terms in a series formed after a given law. When the differences are infinitely small, their calculus belongs to fluxions; but when they are finite, the method of finding their relation to the quantities by which they are produced forms a new calculus, called the integral calculus of finite differences. In consequence of this work, Dr Taylor was attacked anonymously by John Bernouilli, who lavished upon the English geometer all that dull abuse, and angry ridicule, which he had formerly heaped upon his brother.

Problem of reciprocal trajectories. 1716.

79. The problem of reciprocal trajectories was at this time proposed by the Bernouillis. This problem required the curves which, being constructed in two opposite directions in one axis, given in position, and then moving parallel to one another with unequal velocities, should perpetually intersect each other at a given angle. It was long discussed between John Bernouilli and an anonymous writer, who proved to be Dr Pemberton. It was by an elegant solution of this problem that the celebrated Euler began to be distinguished among mathematicians. He was the pupil of John Bernouilli, and continued through the whole of his life, the friend and rival of his son Daniel. The great object of his labours was to extend the boundaries of analysis; and before he had reached his 21st year, he published a new and general method of resolving differential equations of the second order, subjected to certain conditions.

Resolved by Euler, born 1707, died 1783. 1728.

Labours of Count Fagnani.

80. The common algebra had been applied by Leibnitz and John Bernouilli to determine arcs of the parabola, the difference of which is an algebraic quantity, imagining that such problems in the case of the ellipse and hyperbola resisted the application of the new analysis. The Count de Fagnani, however, applied the integral calculus to the arcs of the ellipsis and hyperbola, and had the honour of explaining this new branch of geometry.

Problem of Count Riccati.

81. In the various problems depending on the analysis of infinites, the great difficulty is to resolve the differential equation to which the problems are reduced. Count James Riccati having been puzzled with a differential 1725.
equation of the first order, with two variable quantities, proposed it to mathematicians in the Leipsic Acts for 1725. This question baffled the skill of the most celebrated analysts, who were merely able to point out a number of cases in which the indeterminate can be separated, and the equation resolved by the quadrature of curves.

Problem of Offenburg.

82. Another problem suggested by that of Viviani was proposed in 1718 by Ernest Von Offenburg. It was required to pierce a hemispherical vault with any number of elliptical windows, so that their circumferences should be expressed by algebraic quantities; or in other words, to determine on the surface of a sphere, curves algebraically rectifiable. In a paper on the rectification of spherical epicycloids, Herman * imagined that these curves were algebraically rectifiable, and therefore satisfied the question of Offenburg; but John Bernouilli (Mem. Acad. Par. 1732) demonstrated, that as the rectification of these curves depended on the quadrature of the hyperbola, they were only rectifiable in certain cases, and gave the general method of determining the curves that are algebraically rectifiable on the surface of a sphere.

* *Petersburgh Transactions*, 1726.

Resolved by John Bernouilli.

Labours of Clairaut.

83. The same subject was also discussed by Nicole and Clairaut, (Mem. Acad. 1734). The latter of these mathematicians had already acquired fame by his *Recherches sur les Courbes à double Courbure*, published in 1730, before he was 21 years of age; but his reputation was extended by a method of finding curves whose property consists in a certain relation between these branches expressed by a given equation. In this research, Clairaut pointed out a species of paradox in the integral calculus, which led to the celebrated theory of particular integrals which was afterwards fully illustrated by Euler and other geometers.

Problem of isochronous curves.

84. The celebrated problem of isochronous curves began at this time to be reagitated among mathematicians. The object of this problem is to find such a curve that a heavy body descending along its concavity shall always reach the lowest point in the same time, from whatever point of the curve it begins to descend. Huygens had already shewn that the cycloid was the isochronous curve *in vacuo*. Newton had demonstrated the same curve to be isochronous when the descending body experiences from the air a resistance proportional to its velocity;

Memoirs of Petersburgh, 1729, and Mem. Par. 1730.

locity; and Euler* and John Bernouilli†, had separately found the isochronous curve when the resistance was as the square of the velocity. These three cases, and even a fourth in which the resistance was as the square of the velocity added to the product of the velocity by a constant coefficient, were all resolved by Fontaine, by means of an ingenious and original method; and it is very remarkable that the isochronous curve is the same in the third and fourth cases.—The method of Fontaine was illustrated by Euler, who solved a fifth case, including all the other four, when the resistance is composed of three terms, the square of the velocity, the product of the velocity by a given coefficient, and a constant quantity. He found also an expression of the time which the body employs to descend through any arc of the curve.

Solved by Fontaine.

Algebra of sines and cosines.

85. The application of analytical formulæ to the physico-mathematical sciences was much facilitated by the algebra of sines and cosines with which Frederick Christian Mayer, and Euler, enriched geometry. By the combination of arcs, sines, and cosines, formulæ are obtained which frequently yield to the method of resolution, and enable us to solve a number of problems which the ordinary use of arcs, sines, and cosines, would render tedious and complicated.

Improvement in the resolution of differential equations.

86. About this time a great discovery in the theory of differential equations of the first order was made separately by Euler, Fontaine, and Clairaut. Hitherto geometers had no direct method of ascertaining if any differential equation were resolvable in the state in which it was presented, or if it required some preparation prior to its resolution. For every differential equation a particular method was employed, and their resolution was often effected by a kind of tentative process, which displayed the ingenuity of its author, without being applicable to other equations. The conditions under which differential equations of the first order are resolvable were discovered by the three mathematicians whom we have mentioned. Euler made the discovery in 1736, but did not publish it till 1740. Fontaine and Clairaut lighted upon it in 1739. Euler afterwards extended the discovery to equations of higher orders.

Discovery of the integral calculus with partial differences.

87. The first traces of the integral calculus with partial differences appeared in a paper of Euler's in the Petersburgh Transactions for 1734; but d'Alembert, in his work *Sur les Vents*, has given clearer notions of it, and was the first who employed it in solution of the problem of vibrating cords proposed by Dr Taylor, and investigated by Euler and Daniel Bernouilli. The object of this calculus is to find a function of several variable quantities, when we have the relation of the coefficients which affect the differentials of the variable quantities of which this function is composed. Euler exhibited it in various points of view, and shewed its application to a number of physical problems; and he afterwards, in his paper entitled *Investigatio Functionum ex data Differentialium conditione* ‡, completely explained the nature, and gave the algorithm of the calculus.

‡ *Petersburgh Transactions*, 1762.

The principles of fluxions attacked by Dr Berkeley, 1734.

88. While the analysis of infinites was making such rapid progress on the continent, it was attacked in England by the celebrated Dr Berkeley, bishop of Cloyne, in a work called the *Analyst, or a discourse addressed to an Infidel Mathematician, wherein it is examined whether the object, principles, and inferences of the modern analysis, are more distinctly conceived than Religious Mysteries and Points of Faith.* In this work the doctor admits the truth of the conclusions, but maintains that the principles of fluxions are not founded upon reasoning strictly logical and conclusive. This attack called forth Robins and Maclaurin. The former proved that the principles of fluxions were consistent with the strictest reasoning, while Maclaurin, in his *Treatise of Fluxions*, gave a synthetical demonstration of the principles of the calculus after the manner of the ancient geometricians, and establishes it with such clearness and satisfaction that no intelligent man could refuse his assent. The differential calculus had been attacked at an earlier period by *Nieuwentiet* and *Rolle*, but the weapons wielded by these adversaries were contemptible when compared with the ingenuity of Dr Berkeley.

Works of Thomas Simpson.

89. Notwithstanding this attack upon the principles of the new analysis, the science of geometry made rapid advances in England in the hands of Thomas Simpson, Landen, and Waring. In 1740, Mr Simpson published his *Treatise on Fluxions*, which, besides many original researches, contains a convenient method of resolving differential equations by approximation, and various means of hastening the convergency of slowly converging series. We are indebted to the same geometer for several general theorems for summing different series, whether they are susceptible of an absolute or an approximate summation. His *Mathematical Dissertations*, published in 1743, his *Essays on several Subjects in Mathematics*, published in 1740, and his *Select Exercises for Young Proficients in the Mathematics*, published in 1752, contain ingenious and original researches which contributed to the progress of geometry.

1740.

1743.

The residual analysis invented by Landen. Died in 1777.

90. In his *Mathematical Lucubrations*, published in 1755, Mr Landen has given several ingenious theorems for the summation of series; and the Philosophical Transactions for 1775 contain his curious discovery of the rectification of a hyperbolic arc, by means of two arcs of an ellipsis, which was afterwards more simply demonstrated by Legendre. His invention of a new calculus, called the *residual analysis*, and in some respects subsidiary to the method of fluxions, has immortalized his name. It was announced and explained in a small pamphlet published in 1715, entitled a *Discourse concerning the Residual Analysis*.

Labours of Waring. *Ph. Trans.* 1784, and 1791, p. 146.

91. The progress of geometry in England was accelerated by the labours of Mr Edward Waring, professor of mathematics at Cambridge. His two works entitled *Meditationes Analyticæ*, published in 1769, and *Meditationes Algebraicæ*, and his papers in the Philosophical Transactions on the summation of forces, are filled with original and profound researches into various branches of the common algebra, and the higher analysis.

Discoveries of Lagrange.

92. It was from the genius of Lagrange, however, that the higher calculus has received the most brilliant improvements. This great man was born in Piedmont. He afterwards removed to Berlin, and hence to Paris, where he still resides. In addition to many improvements upon the integral analysis, he has enriched geometry with a new calculus called the *method of variations*. The object of this calculus is, when there is given an expression or function of two or more variable quantities whose relation is expressed by a certain law, to find what this function becomes when that law suffers any variation infinitely;

His method of variations.

ly small, occasioned by the variation of one or more of the terms which express it. This calculus is as much superior to the integral calculus, as the integral calculus is above the common algebra. It is the only means by which we can resolve an immense number of problems *de maximis et minimis*, and is necessary for the solution of the most interesting problems in mechanics.

His theory of analytical functions. His theory of analytical functions is one of the most brilliant specimens of human genius. In the Memoirs of Berlin for 1772 he had touched upon this interesting subject, but the theory was completely developed in 1797 in his work entitled *Theorie des fonctions analytiques, contenant les principes du calcul differentiel, degagées de toute consideration d'infiniments petits, ou evanouissements, ou des limites, ou des fluxions; et reduit à l'analyse algebrique des quantites finies*. In a great number of memoirs which are to be found in the Memoirs of the Academy of Paris, in those of the Academy of Berlin, and in those of the French Academy, Lagrange has thrown light on every branch both of the common algebra and the new analysis.

Labours of La Place. 93. The new geometry has likewise been much indebted to the celebrated Laplace. His various papers in the *Memoires des Sçavans Etrangers* *, and the Memoirs of the French Academy, have added greatly to the higher calculi, while his application of analysis to the celestial phenomena, as exhibited in the *Mechanique Celeste*, and his various discoveries in physical astronomy, entitle him to a high rank among the promoters of science.

* Tom. 6. 7.

Works of Cousin, Lacroix, Bossut, and Legendre. 94. Among the celebrated French mathematicians of the last and present century, we cannot omit the names of Cousin, Lacroix, and Bossut; all of whom have written large works on the differential and integral calculi, and illustrated the new analysis by their discoveries. The *Elemens de Geometrie* by Legendre is one of the best and most original works upon elementary geometry, and his papers in the Memoirs of the Academy contain several improvements upon the new analysis.

Agnesi's analytical institutions. 1784. 95. In Italy the mathematical sciences were destined to be improved and explained by a celebrated female. Donna Maria Gaetana Agnesi (see AGNESI, Supplement) was professor of mathematics in the university of Bologna, and published a learned work entitled *Analytical Institutions*, containing the common analysis, and the differential and integral calculi. It has been translated into English by Professor Colson, and was published at the expence of Baron Maseres. A few years ago several curious properties of the circle have been discovered by Mascheroni, another Italian mathematician, who has published them in his interesting work entitled *sur le Geometrie du Compas*.

Mascheroni on the circle.

English mathematicians. 96. In England the mathematical sciences have been successfully cultivated by Emerson, Baron Maseres, Dr M. Young, Dr Hutton, Professor Vince, and Professor Robertson of Oxford. The *Doctrine of Fluxions* by Emerson, and his *Method of Increments*, are good introductions to the higher geometry.

Emerson.

Baron Maseres. The *Scriptores Logarithmici* of Baron Maseres; his *Tracts on the Resolution of Equations*; his *Principles of Life Annuities*, and his other mathematical papers, do the highest honour to his talents as a mathematician; while his zeal for the promotion of the mathematical sciences, and his generous attention to those who cultivate them, entitle him to the noble appellation of the friend and patron of genius.

Dr M. Young. Dr Matthew Young, bishop of Clonfert, has given a synthetical demonstration of Newton's rule for the quadrature of simple curves; and has written on the extraction of cubic and other roots.

Dr Hutton and Dr Vince. Dr Hutton and Dr Vince have each published several elementary treatises on mathematics, and have invented ingenious methods for the summation of series.

Mr Robertson. Mr Robertson of Oxford is the author of an excellent treatise on conic sections.

Scottish mathematicians. 97. The ancient geometry was assiduously cultivated in Scotland by Dr Robert Simpson and Dr Matthew Stewart.

Dr Simpson. Dr Simpson's edition of Euclid and his treatise on conic sections have been much admired.

Dr M. Stewart. The *Tracts Physical and Mathematical* of Dr Matthew Stewart, and his *Propositiones Geometricæ more veterum demonstratæ* contain fine specimens of mathematical genius. In the present day the names of Professor Playfair and Professor Leslie of the university of Edinburgh, Mr Wallace and Mr Ivory now of the Royal Military College at Great Marlow, are well known to mathematicians.

Mr Playfair. Mr Playfair's Elements of Geometry, and his papers on *the Arithmetic of Impossible Quantities* and on *Porisms*, are proofs of his great talents as a mathematician and a philosopher.

Mr Leslie. Mr Leslie, well known for his great discoveries on heat, has found a very simple principle, capable of extensive application, by which the complicated expressions in the solution of indeterminate problems may be easily resolved.

Mr Wallace. Mr Wallace's papers on *Geometrical Porisms* in the 4th vol. of the Edinburgh Transactions, display much genius;

Mr Ivory. and Mr Ivory's Treatises in the last vol. of Baron Maseres's *Scriptores Logarithmici*, and his paper on *A New Series for the Rectification of the Ellipsis*, Edin. Trans. vol. 4th. entitle him to a high rank among modern mathematicians.

Mathematical, Matlock.

MATHEMATICAL, any thing belonging to the science of mathematics.

Mathematical Instruments, such instruments as are usually employed by mathematicians, as compasses, scales, quadrants, &c.

Machine for dividing Mathematical Instruments. See RAMSDEN's *Machine*.

MATLOCK, a town or village of Derbyshire, near Wicksworth, situated on the very edge of the Derwent; noted for its bath, the water of which is milk-warm; and remarkable for the huge rocks in its environs, particularly those called the *Torr*, which is 140 yards high. It is an extensive straggling village, built in a very romantic style, on the steep side of a mountain, and containing, in 1801, above 2000 inhabitants. Near the bath are several small houses, whose situation is is on the little natural horizontal parts of the mountain, a few yards above the road, and in some places the roofs of some almost touch the floors of others. There are excellent accommodations for company who resort to the bath; and the poorer inhabitants are supported by the sale of petrifactions, crystals, &c. and notwithstanding the rockiness of the soil, the cliffs produce an immense number of trees, whose foliage adds greatly to the beauty of the place.

MATRASS, Cucurbit, or Bolthead, among chemists. See Chemistry, Explanation of Plates.

MATRICARIA, Feverfew; a genus of plants, belonging to the syngenesia class; and in the natural method ranking under the 49th order, *Compositæ*. See Botany *Index*.

MATRICE, or Matrix, See Matrix.

Matrice, or matrix, in *Dyeing*, is applied to the five simple colours, whence all the rest are derived or composed. These are, the black, white, blue, red, and yellow or root colour.

Matrice, or matrices, used by the letter-founders, are those little pieces of copper or brass, at one end whereof are engraven, dentwise, or *en creux*, the several characters used in the composing of books. Each character, virgula, and even each point in a discourse, has its several matrix; and of consequence its several puncheon to strike it. Matrices are cut or graved by engravers in metal.

When types are to be cast, the matrice is fastened to the end of the mould, so disposed, as that when the metal is poured on it, it may fall into the creux or cavity of the matrice, and take the figure and impression thereof. See *Letter Foundery*.

Matrices, used in coining, are pieces of steel in form of dies, whereon are engraven the several figures, arms, characters, legends, &c. wherewith the species are to be stamped. The engraving is performed with several puncheons, which being formed in relievo, or prominent, when struck on the metal, make an indented impression, which the French call *en creux*.

MATRICULA, a register kept of the admission of officers and persons entered into any body or society whereof a list is made. Hence those who are admitted into our universities are said to be matriculated. Among ecclesiastical authors, we find mention made of two kinds of matricule; the one containing a list of the ecclesiastics, called *matricula clericorum*: the other of the poor subsisted at the expence of the church, called *matricula pauperum*.

Matricula was also applied to a kind of almshouse, where the poor were provided for. It had certain revenues appropriated to it, and was usually built near the church, whence the name was also frequently given to the church itself.

MATRIMONY. See Marriage.

MATRIX, in *Anatomy*, the womb, or that part of the female of any kind, wherein the fœtus is conceived and nourished till the time of its delivery. See Anatomy, N° 108.

Matrix is also applied to places proper for the generation of vegetables, minerals, and metals. Thus the earth is the matrix wherein seeds sprout; and marcasites are by many considered as the matrices of metals.

The matrix of ores is the earthy and stony substances in which these metallic matters are enveloped: these are various, as lime and heavy spar, quartz, fluors, &c.

MATRON, an elderly married woman.

Jury of Matrons. When a widow feigns herself with child in order to exclude the next heir, and a supposititious birth is suspected to be intended, then, upon the writ *de ventre inspiciendo*, a jury of women is to be impannelled to try the question whether the woman is with child or not. So, if a woman is convicted of a capital offence, and, being condemned to suffer death, pleads in stay of execution, that she is pregnant, a jury of matrons is impannelled to inquire into the truth of the allegation; and, if they find it true, the convict is respited till after her delivery.

MATRONA, in *Ancient Geography*, a river separating Gallia Celtica from the Belgica (Cæsar). Now the Marne; which, rising in Champagne near Langres, runs north-west, and then west, and passing by Meaux falls into the Seine at Charenton, two leagues to the east of Paris.

MATRONALIA, a Roman festival instituted by Romulus, and celebrated on the kalends of March, in honour of Mars. It was kept by matrons in particular, and bachelors were entirely excluded from any share in the solemnity. The men during this feast sent presents to the women, for which a return was made by them at the Saturnalia: And the women gave the same indulgence to their servants now which the men gave to theirs at the feast of Saturn, serving them at table, and treating them as superiors.

MATROSSES, are soldiers in the train of artillery, who are next to the gunners, and assist them in loading, firing, and spunging the great guns. They carry firelocks, and march along with the store waggons, both as a guard, and to give their assistance in case a waggon should break down.

MATSYS, Quintin, painter of history and portraits, was born at Antwerp in 1460, and for several years followed the trade of a blacksmith or farrier, at least till he was in his 20th year. Authors vary in their accounts of the cause of his quitting his first occupation, and attaching himself to the art of painting. Some affirm, that the first unfolding of his genius was occasioned by the sight of a print which accidentally was shown to him by a friend who came to pay him a visit while he was in a declining state of health from the labour of his former employment, and that by his copying the print with some degree of success, he was animated with a desire to learn the art of painting. Others say, he fell in love with a young woman of great beauty, the daughter of a painter, and they allege that love alone wrought the miracle, as he could have no prospect of obtaining her except by a distinguished merit in the profession of painting: for which reason he applied himself with incessant labour to study and practise the art, till he became so eminent as to be entitled to demand her in marriage, and he succeeded. Whatever truth may be in either of these accounts, it is certain that he appeared to have an uncommon genius; his manner was singular, not resembling the manner of any other master; and his pictures were strongly coloured and carefully finished, but yet they are somewhat dry and hard. By many compe-

Matsys ‖ Matthew.

tent judges it was believed, when they observed the strength of expression in some of his compositions, that if he had studied in Italy to acquire some knowledge of the antiques and the great masters of the Roman school, he would have proved one of the most eminent painters of the Low Countries. But he only imitated ordinary life; and seemed more inclined, or at least more qualified, to imitate the defects than the beauties of nature. Some historical compositions of this master deserve commendation; particularly a Descent from the Cross, which is in the cathedral at Antwerp; and it is justly admired for the spirit, skill, and delicacy of the whole. But the most remarkable and best known picture of Matsys, is that of the Two Misers in the gallery at Windsor. He died in 1529.

MATT, in a ship, is a name given to rope-yarn, junk, &c. beat flat and interwoven; used in order to preserve the yards from galling or rubbing, in hoisting or lowering them.

MATTER, in common language, is a word of the same import with *body*, and denotes that which is tangible, visible, and extended; but among philosophers it signifies that substance of which all bodies are composed; and in this sense it is synonymous with the word ELEMENT.

It is only by the senses that we have any communication with the external world; but the immediate objects of sense, philosophers have in general agreed to term *qualities*, which they conceive as inhering in something which is called their *subject* or *substratum.* It is this substratum of sensible qualities which, in the language of philosophy, is denominated *matter;* so that *matter* is *not* that which we immediately see or handle, but the *concealed subject* or *support* of visible and tangible qualities. What the moderns term *qualities*, was by Aristotle and his followers called *form;* but so far as the two doctrines are intelligible, there appears to be no essential difference between them. From the moderns we learn, that body consists of *matter* and *qualities;* and the Peripatetics taught the same thing, when they said that body is composed of *matter* and *form.*

How philosophers were led to analyze body into matter and form, or, to use modern language, into matter and qualities; what kind of existence they attribute to each; and whether *matter* must be conceived as self-existent or created—are questions which shall be considered afterwards (See METAPHYSICS). It is sufficient here to have defined the term.

MATTHEW, or *Gospel of St MATTHEW*, a canonical book of the New Testament.

St MATTHEW wrote his gospel in Judea, at the request of those he had converted; and it is thought he began in the year 41, eight years after Christ's resurrection. It was written, according to the testimony of all the ancients, in the Hebrew or Syriac language; but the Greek version, which now passes for the original, is as old as the apostolical times.

St MATTHEW the Evangelist's Day, a festival of the Christian church, observed on September 21st.

St MATTHEW, the son of Alpheus, was also called *Levi.* He was of a Jewish original, as both his names discover, and probably Galilean. Before his call to the apostolate, he was a publican or toll-gatherer to the Romans; an office of bad repute among the Jews, on account of the covetousness and exaction of those who managed it; St Matthew's office particularly consisting in gathering the customs of all merchandise that came by the sea of Galilee, and the tribute that passengers were to pay who went by water. And here it was that Matthew sat at the receipt of customs, when our Saviour called him to be a disciple. It is probable, that, living at Capernaum, the place of Christ's usual residence, he might have some knowledge of him before he was called. Matthew immediately expressed his satisfaction in being called to this high dignity, by entertaining our Saviour and his disciples at a great dinner at his own house, whither he invited all his friends, especially those of his own profession, hoping, probably, that they might be influenced by the company and conversation of Christ. St Matthew continued with the rest of the apostles till after our Lord's ascension. For the first eight years afterwards, he preached in Judea. Then he betook himself to propagating the gospel among the Gentiles, and chose Ethiopia as the scene of his apostolical ministry; where it is said he suffered martyrdom, but by what kind of death is altogether uncertain. It is pretended, but without any foundation, that Hyrtaeus, king of Ethiopia, desiring to marry Iphigenia, the daughter of his brother and predecessor Æglippus, and the apostle having represented to him that he could not lawfully do it, the enraged prince ordered his head immediately to be cut off. Baronius tells us, the body of St Matthew was transported from Ethiopia to Bithynia, and from thence was carried to Salernum in the kingdom of Naples in the year 954, where it was found in 1080, and where Duke Robert built a church bearing his name.

Matthew, Matthias.

St MATTHEW, a town of Spain, in the kingdom of Arragon, seated in a pleasant plain, and in a very fertile country watered with many springs. W. Long. 0. 15. N. Lat. 40. 22.

MATTHEW of Paris. See PARIS.

MATTHEW of Westminster, a Benedictine monk and accomplished scholar, who wrote a history from the beginning of the world to the end of the reign of Edward I. under the title of *Flores Historiarum;* which was afterwards continued by other hands. He died in 1380.

St MATTHIAS, an apostle, was chosen instead of Judas. He preached in Judea and part of Ethiopia, and suffered martyrdom. See the *Acts of the Apostles*, chap. i. There was a gospel published under Matthias's name, but rejected as spurious; as likewise some traditions, which met with the same fate.

St MATTHIAS's Day, a festival of the Christian church, observed on the 24th of February. St Matthias was an apostle of Jesus Christ, but not of the number of the twelve chosen by Christ himself. He obtained this high honour upon a vacancy made in the college of the apostles by the treason and death of Judas Iscariot. The choice fell on Matthias by lot; his competitor being Joseph called *Barsabas*, and surnamed *Justus.* Matthias was qualified for the apostleship, by having been a constant attendant upon our Saviour all the time of his ministry. He was, probably, one of the 70 disciples. After our Lord's resurrection, he preached the gospel first in Judea.

Afterwards

Matthias || Maty. Afterwards it is probable he travelled eastward, his residence being principally near the irruption of the river Apsarus and the haven Hyssus. The barbarous people treated him with great rudeness and inhumanity; and, after many labours and sufferings in converting great numbers to Christianity, he obtained the crown of martyrdom; but by what kind of death, is uncertain.—They pretend to show the relics of St Matthias at Rome; and the famous abbey of St Matthias near Treves boasts of the same advantage; but doubtless both without any foundation. There was a gospel ascribed to St Matthias; but it was universally rejected as spurious.

MATTIACÆ Aquæ, or Mattiaci Fontes, in *Ancient Geography*, now Wisbaden, opposite to Mentz, in Weteravia. E. Long. 8. N. Lat. 50. 6.

MATTIACUM, or Mattium, in *Ancient Geography*, a town of the Mattiaci, a branch of the Catti in Germany. Now Marpurg in Hesse. E. Long. 8. 40. N. Lat. 50. 40.

MATTINS, the first canonical hour, or the first part of the daily service in the Romish church.

MATTHIOLUS, Peter Andrew, an eminent physician in the 16th century, born at Sienna, was well skilled in the Greek and Latin tongues. He wrote learned commentaries on Dioscorides, and other works which are esteemed; and died in 1577.

MATURANTS, in *Pharmacy*, medicines which promote the suppuration of tumors.

MATY, Matthew, M. D. an eminent physician and polite writer, was born in Holland in the year 1718. He was the son of a clergyman, and was originally intended for the church; but in consequence of some mortifications his father met with from the synod, on account of the peculiar sentiments he entertained about the doctrine of the Trinity, turned his thoughts to physic. He took his degree of M. D. at Leyden; and in 1740 came to settle in England, his father having determined to quit Holland for ever. In order to make himself known, he began in 1749 to publish in French an account of the productions of the English press, printed at the Hague under the name of the *Journal Britannique*. This journal, which continues to hold its rank amongst the best of those which have appeared since the time of Bayle, answered the chief end he intended by it, and introduced him to the acquaintance of some of the most respectable literary characters of the country he had made his own. It was to their active and uninterrupted friendship he owed the places he afterwards possessed. In 1758 he was chosen fellow, and in 1765, on the resignation of Dr Birch, who died a few months after, and had made him his executor, secretary to the Royal Society. He had been appointed one of the under librarians of the British museum at its first institution in 1753, and became principal librarian at the death of Dr Knight in 1772. Useful in all these situations, he promised to be eminently so in the last, when he was seized with a languishing disorder, which in 1776 put an end to a life which had been uniformly devoted to the pursuit of science and the offices of humanity. He was an early and active advocate for inoculation; and when there was a doubt entertained that one might have the smallpox this way a second time, tried it upon himself unknown to his family. He was a member of the medical club (with the Drs Parsons, Templeman, Fothergill, Watson and others), which met every fortnight in St Paul's Churchyard. He was twice married, viz. the first time to Mrs Elizabeth Boisragon; and the second to Mrs Mary Deners. He left a son and three daughters. He had nearly finished the Memoirs of the earl of Chesterfield; which were completed by his son-in-law Mr Justamond, and prefixed to that nobleman's Miscellaneous Works, 1777, 2 vols 4to.

Maty. Maubeuge.

Maty, *Paul Henry*, M. A. F. R. S. son of the former, was born in 1745, and was educated at Westminster and Trinity college, Cambridge, and had their travelling fellowship for three years. He was afterwards chaplain to Lord Stormont at Paris, and soon after vacated his next fellowship by marrying one of the three daughters of Joseph Clerk, Esq. and sister of Captain Charles Clerk (who succeeded to the command on the death of Captain Cook). On his father's death in 1776, he was appointed to the office of one of the under librarians of the British Museum, and was afterwards preferred to a superior department, having the care of the antiquities, for which he was eminently qualified. In 1776 he also succeeded his father in the office of secretary to the Royal Society. On the disputes respecting the reinstatement of Dr Hutton in the department of secretary for foreign correspondence in 1784, Mr Maty took a warm and distinguised part, and resigned the office of secretary; after which he undertook to assist gentlemen or ladies in perfecting their knowledge of the Greek, Latin, French, and Italian classics. Mr Maty was a thinking conscientious man; and having conceived some doubts about the articles he had subscribed in early life, he never could be prevailed upon to place himself in the way of ecclesiastical preferment, though his connexions were amongst those who could have served him essentially in this point; and soon after his father's death he withdrew himself from ministering in the established church, his reasons for which he published in the 47th volume of the Gent. Magazine, p. 466. His whole life was thenceforwards taken up in literary pursuits. He received 100l. from the duke of Marlborough, with a copy of that beautiful work, the *Gemmæ Marlburienses*, of which only 100 copies were worked off for presents; and of which Mr Maty wrote the French account, as Mr Bryant did the Latin. In January 1782 he set on foot a Review of publications, principally foreign, which he carried on, with great credit to himself and satisfaction to the public, for near five years, when he was obliged to discontinue it from ill health. He had long laboured under an asthmatic complaint, which at times made great ravages in his constitution, and at last put a period to his life in Jan. 1787, at the age of 42; leaving behind him one son.—Mr Maty was eminently acquainted with ancient and modern literature, and particularly conversant in critical researches. The purity and probity of his nature were unquestionable; and his humanity was as exquisite as it would have been extensive, had it been seconded by his fortune.

MAUBEUGE, a fortified town of the Netherlands, in Hainault, which formerly contained an abbey of canonesses, who were noble both by the father and mother's side. In 1678 this place was ceded to France, in whose possession it still remains. In September 1793, 1793, the Austrians formed the blockade of this place, but were driven from their position in the following month. It is seated on the river Sambre, in E. Long. 4. 2. N. Lat. 50. 16.

MAUCAUCO, MACACO, or *Maki*, a genus of quadrupeds belonging to the order *Primates*. See MAMMALIA *Index*.

MAVIS, a species of turdus. See ORNITHOLOGY *Index*.

MAUNCH, in *Heraldry*, the figure of an ancient coat sleeve, borne in many gentlemen's escutcheons.

MAUNDY THURSDAY, is the Thursday in passion week; which was called *Maunday*, or *Mandate Thursday*, from the command which our Saviour gave his apostles to commemorate him in the Lord's supper, which he this day instituted; or from the new commandment which he gave them to love one another, after he had washed their feet as a token of his love to them.

MAUPERTUIS, PETER LOUIS MORCEAU DE, a celebrated French academician, was born at St Malo in 1698; and was there privately educated till he arrived at his 16th year, when he was placed under the celebrated professor of philosophy M. le Blond, in the college of La Marche, at Paris. He soon discovered a passion for mathematical studies, and particularly for geometry. He likewise practised instrumental music in his early years with great success, but fixed on no profession till he was 20, when he entered into the army. He first served in the Grey musqueteers; but in the year 1720, his father purchased for him a company of cavalry in the regiment of La Rocheguyon. He remained but five years in the army, during which time he pursued his mathematical studies with great vigour; and it was soon remarked by M. Freret and other academicians, that nothing but geometry could satisfy his active soul and unbounded thirst for knowledge. In the year 1723, he was received into the Royal Academy of Sciences, and read his first performance, which was a memoir upon the construction and form of musical instruments, November 15. 1724. During the first years of his admission, he did not wholly confine his attention to mathematics; he dipt into natural philosophy, and discovered great knowledge and dexterity in observations and experiments upon animals. If the custom of travelling into remote climates, like the sages of antiquity, in order to be initiated into the learned mysteries of those times had still subsisted, no one would have conformed to it with greater eagerness than M. de Maupertuis. His first gratification of this passion was to visit the country which had given birth to Newton: and during his residence at London he became as zealous an admirer and follower of that philosopher as any one of his own countrymen. His next excursion was to Basil in Switzerland, where he formed a friendship with the famous John Bernouilli and his family, which continued to his death. At his return to Paris, he applied himself to his favourite studies with greater zeal than ever:—And how well he fulfilled the duties of an academician, may be gathered by running over the memoirs of the academy from the year 1724 to 1736; where it appears that he was neither idle nor occupied by objects of small importance. The most sublime questions in geometry and the relative sciences received from his hands that elegance, clearness, and precision, so remarkable in all his writings. In the year 1736, he was sent by the king of France to the polar circle to measure a degree, in order to ascertain the figure of the earth, accompanied by Messrs Clairault, Camus, Le Monnier, l'Abbe Outhier, and Celsius the celebrated professor of astronomy at Upsal. This distinction rendered him so famous, that at his return he was admitted a member of almost every academy in Europe.

In the year 1740 Maupertuis had an invitation from the king of Prussia to go to Berlin; which was too flattering to be refused. His rank among men of letters had not wholly effaced his love for his first profession, namely that of arms. He followed his Prussian majesty into the field, and was a witness of the dispositions and operations that preceded the battle of Molwitz; but was deprived of the glory of being present, when victory declared in favour of his royal patron, by a singular kind of adventure. His horse, during the heat of the action, running away with him, he fell into the hands of the enemy; and was at first but roughly treated by the Austrian soldiers, to whom he could not make himself known for want of language; but being carried prisoner to Vienna, he received such honours from their Imperial Majesties as were never effaced from his memory. From Vienna he returned to Berlin; but as the reform of the academy which the king of Prussia then meditated was not yet mature, he went again to Paris, where his affairs called him, and was chosen in 1742 director of the Academy of Sciences. In 1753 he was received into the French academy; which was the first instance of the same person being a member of both the academies at Paris at the same time. M. de Maupertuis again assumed the soldier at the siege of Fribourg, and was pitched upon by Marshal Cogny and the Count d'Argenson to carry the news to the French king of the surrender of that citadel.

He returned to Berlin in the year 1744, when a marriage was negotiated and brought about by the good offices of the queen-mother, between our author and Mademoiselle de Borek, a lady of great beauty and merit, and nearly related to M. de Borck, at that time minister of state. This determined him to settle at Berlin, as he was extremely attached to his new spouse, and regarded this alliance as the most fortunate circumstance of his life.

In the year 1746, M. de Maupertuis was declared by his Prussian majesty president of the Royal Academy of Sciences at Berlin, and soon after by the same prince was honoured with the order of Merit: However, all these accumulated honours and advantages, so far from lessening his ardour for the sciences, seemed to furnish new allurements to labour and application. Not a day passed but he produced some new project or essay for the advancement of knowledge. Nor did he confine himself to mathematical studies only: metaphysics, chemistry, botany, polite literature, all shared his attention, and contributed to his fame. At the same time, he had, it seems, a strange inquietude of spirit, with a morose temper, which rendered him miserable amidst honours and pleasures.—Such a temperament did not promise a very pacific life, and he was engaged in several quarrels. He had a

Maupertuis. a quarrel with Koenig the professor of philosophy at Franeker, and another more terrible with Voltaire. Maupertuis had inserted into the volume of Memoirs of the Academy of Berlin for 1746, a discourse upon the laws of motion; which Koenig was not content with attacking, but attributed to Leibnitz. Maupertuis, stung with the imputation of plagiarism, engaged the academy of Berlin to call upon him for his proof; which Koenig failing to produce, he was struck out of the academy, of which he was a member. Several pamphlets were the consequence of this; and Voltaire, for some reason or other, engaged against Maupertuis. We say, for some reason or other; because Maupertuis and Voltaire were apparently upon the most amicable terms; and the latter respected the former as his master in the mathematics. Voltaire, however, exerted all his wit and satire against him; and on the whole was so much transported beyond what was thought right, that he found it expedient in 1753 to quit the court of Prussia.

Our philosopher's constitution had long been considerably impaired by the great fatigues of various kinds in which his active mind had involved him; though from the amazing hardships he had undergone in his northern expedition, most of his future bodily sufferings may be traced. The intense sharpness of the air could only be supported by means of strong liquors, which served to increase his disorder, and bring on a spitting of blood, which began at least 12 years before he died. Yet still his mind seemed to enjoy the greatest vigour; for the best of his writings were produced, and most sublime ideas developed, during the time of his confinement by sickness, when he was unable to occupy his presidial chair at the academy. He took several journeys to St Malo, during the last years of his life, for the recovery of his health: And though he always received benefit by breathing his native air, yet still, upon his return to Berlin, his disorder likewise returned with greater violence.—His last journey into France was undertaken in the year 1757; when he was obliged, soon after his arrival there, to quit his favourite retreat at St Malo, on account of the danger, and confusion which that town was thrown into by the arrival of the English in its neighbourhood. From thence he went to Bourdeaux, hoping there to meet with a neutral ship to carry him to Hamburgh, in his way back to Berlin; but being disappointed in that hope, he went to Thoulouse, where he remained seven months. He had then thoughts of going to Italy, in hopes a milder climate would restore him to health: but finding himself grow worse, he rather inclined towards Germany, and went to Neufchatel, where for three months he enjoyed the conversation of Lord Marischal, with whom he had formerly been much connected. At length he arrived at Basil, October 16. 1758, where he was received by his friend Bernouilli and his family with the utmost tenderness and affection. He at first found himself much better here than he had been at Neufchatel: but this amendment was of short duration; for as the winter approached, his disorder returned, accompanied by new and more alarming symptoms. He languished here many months during which he was attended by M. de la Condamine; and died in 1759.

He wrote in French, 1. The figure of the earth determined. 2. The measure of a degree of the meridian. 3. A discourse on the parallax of the moon. 4. A discourse on the figure of the stars. 5. The elements of geography. 6. Nautical astronomy. 7. Elements of astronomy. 8. A physical dissertation on a white inhabitant of Africa. 9. An essay on cosmography. 10. Reflections on the origin of languages. 11. An essay on moral philosophy. 12. A letter on the progress of the sciences. 13. An essay on the formation of bodies. 14. An eulogium on M. de Montesquieu. 15. Letters, and other works.

Maupertuis || Maurice.

MAUR, St, was a celebrated disciple of St Benedict. If we can believe a life of St Maur ascribed to Faustus his companion, he was sent by Benedict on a mission to France. But this life is considered as apocryphal. In rejecting it, however, as well as the circumstances of the mission, we must beware of denying the mission itself. It is certain that it was believed in France as early as the 9th century; and notwithstanding the silence of Bede, Gregory of Tours, and others, there are several documents which prove this, or at least render it extremely probable. A celebrated society of Benedictines, took the name of *St Maur* in the beginning of the last century, and received the sanction of Pope Gregory XV. in 1621. This society was early distinguished by the virtue and the knowledge of its members, and it still supports the character. There are, perhaps, fewer eminent men in it than formerly; but this may be ascribed to the levity of the age, and partly to the little encouragement for the researches of learned men. The chief persons of ingenuity which this society has produced are, the Fathers Menard, d'Acheri, Mabillon, Ruinart, Germain, Lami, Montfaucon, Martin, Vaissette, le Nourri, Martianay, Martenne, Massuet, &c. &c. See *L'Histoire Litteraire de la Congregation de St Maur*, published at Paris under the title of *Brussels*, in 4to, 1770, by Dom. Tassin.

MAURICEAU, Francis, a French surgeon, who applied himself with great success and reputation to the theory and practice of his art for several years at Paris. Afterwards he confined himself to the disorders of pregnant and lying-in-women, and was at the head of all the operators in this way. His *Observations sur la grossesse* and *sur l'accouchement des femmes, sur leurs maladies, et celles des enfans nouveaux*, 1694, in 4to, is reckoned an excellent work, and has been translated into several languages, German, Flemish, Italian, English: and the author himself translated it into Latin. It is illustrated with cuts. He translated another piece or two, by way of supplement, on the same subject; and died at Paris in 1709.

MAURICE, St, commander of the Theban legion, was a Christian, together with the officers and soldiers of that legion, amounting to 6600 men.—This legion received its name from the city Thebes in Egypt, where it was raised. It was sent by Dioclesian to check the Bagaudæ, who had excited some disturbances in Gaul. Maurice having carried his troops over the Alps, the emperor Maximinian commanded him to employ his utmost exertions to extirpate Christianity. This proposal was received with horror both by the commander and by the soldiers. The emperor, enraged at their opposition, commanded the legion to be decimated; and when they still

Maurice. declared that they would sooner die than do any thing prejudicial to the Christian faith, every tenth man of those who remained was put to death. Their perseverance excited the emperor to still greater cruelty; for when he saw that nothing could make them relinquish their religion, he commanded his troops to surround them, and cut them to pieces. Maurice, the commander of these Christian heroes, and Exuperus and Candidus, officers of the legion, who had chiefly instigated the soldiers to this noble resistance, signalized themselves by their patience and their attachment to the doctrines of the Christian religion. They were massacred, it is believed, at Agaune, in Chablais, the 22d of September 286.—Notwithstanding many proofs which support this transaction, Dubordier, Hottinger, Moyle, Burnet, and Mosheim, are disposed to deny the fact. It is defended, on the other hand, by Hicks an English writer, and by Dom Joseph de Lisle a Benedictine monk *de la congregration de Saint Vannes*, in a work of his, entitled *Defence de la Verité du Martyre de la Legion Thebenne*, 1737. In defence of the same fact, the reader may consult *Historia de S. Mauritie*, by P. Rossignole a Jesuit, and the *Acta Sanctorum* for the month of September. The martyrdom of this legion, written by St Eucherius bishop of Lyons, was transmitted to posterity in a very imperfect manner by Surius. P. Chifflet a Jesuit, discovered, and gave to the public, an exact copy of this work. Don Ruinart maintains, that it has every mark of authenticity. St Maurice is the patron of a celebrated order in the king of Sardinia's dominions, created by Emanuel Philibert duke of Savoy, to reward military merit, and approved by Gregory XIII. in 1572. The commander of the Theban legion must not be confounded with another *St Maurice*, mentioned by Theodoret, who suffered martyrdom at Apamea in Syria.

Maurice, (*Mauritius Tiberius*), was born at Arabissus in Cappadocia, A. D. 539. He was descended from an ancient and honourable Roman family.—After he had filled several offices in the court of Tiberius Constantine, he obtained the command of his armies against the Persians. His gallantry was so conspicuous that the emperor gave him his daughter Constantina in marriage, and invested him with the purple the 13th August 582. The Persians still continued to make inroads on the Roman territories, and Maurice sent Philippicus, his brother-in-law, against them. This general conducted the war with various success. At first he gained several splendid victories, but he did not continue to have a decided superiority. As there was a great use for soldiers in these unfortunate times, the emperor issued a mandate in 592, forbidding any soldier to become a monk till he had accomplished the term of his military service. Maurice acquired much glory in restoring Chosroes II. king of Persia, to the throne, after he had been deposed by his subjects. The empire was in his reign harassed by the frequent inroads of the Arabian tribes. He purchased peace from them, by granting them a pension nearly equal to 100,000 crowns; but these barbarians took frequent opportunities to renew the war. In different engagements the Romans destroyed 50,000, and took 17,000 prisoners. These were restored, on condition that the king of the Abari should return all the Roman captives in his dominions. Maurice. Regardless of his promise, he demanded a ransom of 10,000 crowns. Maurice, full of indignation, refused the sum: and the barbarian, equally enraged, put the captives to the sword. While the emperor, to revenge this cruelty, was making preparations against the Abari, Phocas, who from the rank of centurion had attained the highest military preferment, assumed the purple, and was declared emperor. He pursued Maurice to Chalceden, took him prisoner, and condemned him to die. The five sons of this unfortunate prince were massacred before his eyes, and Maurice, humbling himself under the hand of God, was heard to exclaim, *Thou art just, O Lord, and thy judgments are without partiality*. He was beheaded on the 26th November 602, in the 63d year of his age and 20th of his reign. Many writers have estimated the character of this prince by his misfortunes instead of his actions. They believed him guilty without evidence, and condemned him without reason. It cannot be denied, however, that he allowed Italy to be harassed; but he was a father to the rest of the empire. He restored the military discipline, humbled the pride of his enemies, supported the Christian religion by his laws, and piety by his example. He loved the sciences, and was the patron of learned men.

Maurice, elector of Saxony, son of Henry le Pieux, was born A. D. 1521. He was early remarkable for his courage, and during his whole life he was engaged in warlike pursuits. He served under the emperor Charles V. in the campaign of 1544 against France; and in the year following against the league of Smalkalde; with which, although a Protestant, he would have no manner of connexion. The emperor, as a reward for his services, in the year 1547, made him elector of Saxony, having deprived his cousin John Frederick of that electorate. Ambition had led him to second the views of Charles, in the hope of being elector, and ambition again detached him from that prince. In 1551 he entered into a league against the emperor, together with the elector of Brandenburgh, the Count Palatine, the duke of Wirtemburg, and many other princes. This league, encouraged by the young and enterprising Henry II. of France, was more dangerous than that of Smalkalde. The pretext for the association was the deliverance of the landgrave of Hesse, whom the emperor kept prisoner. Maurice and the confederates marched, in 1552, to the defiles of Tyrol, and put to flight the Imperial troops who guarded them. The emperor and his brother Ferdinand narrowly escaped, and fled from the conquerors in great disorder. Charles having retired into Passau, where he had collected an army, brought the princes of the league to terms of accommodation. By the famous peace of Passau, which was finally ratified the 12th of August 1552, the emperor granted an amnesty without exception to all those who had carried arms against him from the year 1546. The Protestants not only obtained the free exercise of their religion, but they were admitted into the imperial chamber, from which they had been excluded since the victory of Mulberg.—Maurice soon after united himself with the emperor against the margrave of Brandenburg, who laid waste the German provinces. He engaged him in 1553, gained

Maurice. ed the battle of Sivershausen, and died of the wounds he had received in the engagement two days after. He was one of the greatest protectors of the Lutherans in Germany, and a prince equally brave and politic. After he had profited by the spoils of John Frederick, the chief of the Protestants, he became himself the leader of the party, and by these means maintained the balance of power against the emperor in Germany.

Maurice de Nassau, Prince of Orange, succeeded to the government of the Low Countries after the death of his father William, who was killed in 1584 by the fanatic Gerard. The young prince was then only eighteen years of age, but his courage and abilities were above his years. He was appointed captain general of the United Provinces, and he reared that edifice of liberty of which his father had laid the foundation. Breda submitted to him in 1590; Zutphen, Deventer, Hulst, Nimeguen, in 1591. He gained several important advantages in 1592, and in the year following he made himself master of Gertrudenburg. When he had performed these splendid services, he returned to the Low Countries by the way of Zealand. His fleet was attacked by a dreadful tempest, in which he lost forty vessels, and he himself had very nearly perished. His death would have been considered by the Hollanders as a much greater calamity than the loss of their vessels. They watched over his safety with exceeding care. In 1594, one of his guards was accused of an intention to take away his life; and it was generally believed that he was bribed to this service by the enemies of the republic. He fell a sacrifice at Bruges, either to his own fanaticism or to the jealous anxiety of the friends of Maurice. The prince of Orange, increasing in reputation, defeated the troops of the archduke Albert in 1597, and drove the Spaniards entirely out of Holland. In 1600 he was obliged to raise the siege of Dunkirk; but he took ample vengeance on Albert, whom he again defeated in a pitched battle near Nieuport. Before the action, this great general sent back the ships which had brought his troops into Flanders: *My brethren* (said he to his army), *we must conquer the enemy or drink up the waters of the sea. Determine for yourselves; I have determined I shall either conquer by your bravery, or I shall never survive the disgrace of being conquered by men in every respect our inferiors.* This speech elevated the soldiers to the highest pitch of enthusiasm, and the victory was complete. Rhinberg, Grave, and Ecluse, cities in Flanders, submitted to the conqueror the following year. Maurice, however, not only laboured for the commonwealth, but also for himself. He coveted the sovereignty of Holland, and was opposed in the prosecution of his design by the pensioner Barneveldt. The zeal and activity of this wise republican cost him his life. He was an Arminian; and at this time Maurice defended Gomar against Arminius.—Taking advantage of the general odium under which the Arminians lay, he found means to get Barneveldt condemned in 1619. His death, wholly owing to the cruel ambition of the Prince of Orange, made a deep impression on the minds of the Hollanders. The truce with Spain being expired, Spinola laid siege to Breda in 1624, and in six months, by the proper direction of his great talents, though with great slaughter of his troops, he took the place. The prince of Orange, unsuccessful in every attempt to raise the siege, died of vexation in 1625, aged 55 years, with the reputation of the greatest warrior of his time.—"The life of this stadtholder (says the abbe Raynal) was almost an uninterrupted series of battles, of sieges, and of victories. Of moderate abilities in every thing else, he shone conspicuous in his military capacity. His camp was the school of Europe; and those who received their military education in his armies augmented, perhaps, the glory of their master.—Like Montecuculi, he discovered inimitable skill in his marches and encampments; like Vauban, he possessed the talent of fortifying places, and of rendering them impregnable; like Eugene, the address of finding subsistence for great armies in countries barren by nature, or ravaged by war; like Vendome, the happy talent of calling forth, in the moment they became necessary, greater exertions from his soldiers than could reasonably be expected; like Condé, that infallible quickness of eye which decides the fortune of battles; like Charles XII. the art of rendering his troops almost invincible to cold, hunger, and fatigue; like Turenne, the secret of making war with the least possible expence of human blood." The Chevalier Folard maintains, that Maurice was the greatest commander of infantry since the time of the Romans. He studied the military art of the ancients, and applied their rules with great exactness in the various occurrences of war. He not only took advantage of the inventions of others, but he enriched the science of war with several improvements. Telescopes were first used by him for a military purpose; and, besides a kind of gallery in conducting a siege, and the plan of blockading a strong place, which were of his invention, he greatly improved the whole art by his method of pushing an attack with great vigour, and of defending, for the greatest length of time, and in the best manner, a place besieged. In short, the many useful things which he practised or invented, placed him in the highest rank among men of a military character. On one occasion, a lady of quality asked him, *Who was the first general of the age? Spinola* (replied he) *is the second.* It was his constant practice, during sleep, to have two guards placed by his bedside, not only to defend him in case of danger, but to awake him if there should be the least occasion. The war betwixt Spain and Holland was never carried on with greater keenness and animosity than during his administration.—The Grand Signior, hearing of the vast torrents of blood shed in this contest, thought that a great empire must depend on the decision. The object of so many battles was pointed out to him on a map, and he said coldly, *If it were my business, I would send my pioneers, and order them to cast this little corner of earth into the sea.* Maurice, like many great men, was impatient under contradiction, and too much devoted to women. He was succeeded by Frederick Henry his brother.

Mauritania. MAURITANIA, an ancient kingdom of Africa, bounded on the west by the Atlantic ocean, on the south by Getulia or Libya Interior, and on the north by the Mediterranean; comprehending the greater part of the kingdoms of Fez and Morocco.—Its ancient limits are not exactly mentioned by any historian; neither

Mauritania.

neither can they now be ascertained by any modern observations, these kingdoms being but little known to Europeans.

This country was originally inhabited by a people called *Mauri*, concerning the etymology of which name authors are not agreed. It is probable, however, that this country, or at least great part of it, was first called *Phut*, since it appears from Pliny, Ptolemy, and St Jerome, that a river and territory not far from Mount Atlas went by that name. From the Jerusalem Targum it likewise appears, that part of the Mauri may be deemed the offspring of Lud the son of Misraim, since his descendants, mentioned Genesis x. are there called מדרטאי, *Mauri*, or *Mauritani*. It is certain, that this region, as well as the others to the eastward of it, had many colonies planted in it by the Phœnicians. Procopius tells us, that in his time two pillars of white stone were to be seen there, with the following inscription in the Phœnician language and character upon them: "We are the *Canaanites*, that fled from *Joshua* the son of Nun, that notorious robber." *Ibnu Rachic*, or *Ibnu Raquig*, an African writer cited by Leo, together with Evagrius and Nicephorus Callistus, assert the same thing.

The Mauritanians, according to Ptolemy, were divided into several cantons or tribes. The *Metagonitæ* were seated near the straits of Hercules, now those of Gibraltar. The *Saccosii*, or *Cocosii*, occupied the coast of the Iberian sea. Under these two petty nations the *Masices*, *Verues*, and *Verbicæ* or *Vervicæ*, were settled. The *Salisæ* or *Salinsæ*, were situated lower, towards the ocean; and, still more to the south, the *Volubiliani*. The *Maurensii* and *Herpiditani* possessed the eastern part of this country, which was terminated by the *Mulucha*. The *Angaucani*, or *Jangacaucani*, *Nectiberes*, *Zagrensii*, *Baniubæ*, and *Vacuntæ*, extended themselves from the southern foot of Ptolemy's Atlas Minor to his Atlas Major. Pliny mentions the *Baniuræ*, whom Father Hardouin takes to be Ptolemy's Baniubæ; and Mela the Atlantes, whom he represents as possessed of the western part of this district.

The earliest prince of Mauritania mentioned in history is Neptune; and next to him were Atlas and Antæus his two sons, both famous in the Grecian fables on account of their wars with Hercules. Antæus, in his contention with that hero, seems to have behaved with great bravery and resolution. Having received large reinforcements of Libyan troops, he cut off great numbers of Hercules's men. But that celebrated commander, having at last intercepted a strong body of Libyans sent to the relief of Antæus, gave him a total overthrow, wherein both he and the best part of his forces were put to the sword. This decisive action put Hercules in possession of Libya and Mauritania, and consequently of the riches of all these kingdoms. Hence came the fable, that Hercules, finding Antæus, a giant of an enormous size with whom he was engaged in single combat, to receive fresh strength as often as he touched his mother earth when thrown upon her, at last lifted him up in the air and squeezed him to death. Hence likewise may be deduced the fable intimating that Hercules took the globe from Atlas upon his own shoulders, overcame the dragon that guarded the orchards of the Hesperides, and made himself master of all the golden fruit there. Bochart thinks that the fable alluded chiefly to naval engagements, wherein Hercules, for the most part, was victorious; though Antæus from time to time received succours by sea. But at last Hercules, coming up with one of his squadrons which had a strong reinforcement on board, made himself master of it, and thus rendered Antæus incapable for the future of making head against him. The same author likewise insinuates, that the notion of Antæus's gigantic stature prevailing for so many centuries amongst the Tingitanians, pointed out the size of the vessels of which his fleets and squadrons were composed. As for the golden apples so frequently mentioned by the old mythologists, they were the treasures that fell into Hercules's hands upon the defeat of Antæus; the Greeks giving the oriental word מאל *riches*, the signification affixed to their own term *μηλα*, *apples*.

With regard to the age in which Atlas and Antæus lived, the most probable supposition seems to be that of Sir Isaac Newton. According to that illustrious author, Ammon the father of Sesac was the first king of Libya, or that vast tract extending from the borders of Egypt to the Atlantic ocean; the conquest of which country was effected by Sesac in his father's lifetime. Neptune afterwards excited the Libyans to a rebellion against Sesac, and slew him; and then invaded Egypt under the command of Atlas or Antæus, the son of Neptune, Sesac's brother and admiral. Not long after, Hercules, the general of Thebais and Ethiopia for the gods or great men of Egypt, reduced a second time the whole continent of Libya, having overthrown and slain Antæus near a town in Thebais, from that event called *Antæa* or *Antæopolis*: this, we say, is the notion advanced by Sir Isaac Newton, who endeavours to prove, that the first reduction of Libya, by Sesac, happened a little above a thousand years before the birth of Christ, as the last, by Hercules, did some few years after. Now, though we do not pretend to adopt every particular circumstance of Sir Isaac Newton's system, yet we cannot forbear observing, that it appears undeniably plain from Scripture, that neither the western extremity of Libya, nor even the other parts of that region, could possibly have been so well peopled before the time of David or Solomon, as to have sent a numerous army to invade Egypt. For Egypt and Phœnicia, from whence the greatest part of the ancestors of the Libyans came, and which were much nearer the place from whence the first dispersion of mankind was made, could not themselves have been greatly overstocked with inhabitants any considerable time before the reign of Saul. And that such an invasion happened in the reign of Neptune, or at least of his son Antæus, has been most fully evinced by this most excellent chronologer.

From the defeat of Antæus, nothing remarkable occurs in the history of Mauritania till the times of the Romans, who at last brought the whole kingdom under their jurisdiction; for which see the article ROME. 1. With regard to the customs, &c. of this people, it would seem, from what Hyginus insinuates, that they fought only with clubs, till one Belus, the son of Neptune, as that author calls him, taught

them

them the use of the sword. Sir Isaac Newton makes this Belus to have been the same person with Sesostris king of Egypt, who overran a great part of the then known world. 2. All persons of distinction in Mauritania went richly attired, wearing much gold and silver in their clothes. They took great pains in cleansing their teeth, and curled their hair in a curious and elegant manner. They combed their beards, which were very long, and always had their nails pared extremely close. When they walked out in any numbers, they never touched one another, for fear of disconcerting the curls into which their hair had been formed. 3. The Mauritanian infantry, in time of action, used shields made of elephants skins, being clad in those of lions, leopards, and bears, which they kept on both night and day. 4. The cavalry of this nation was armed with broad short lances, and carried targets or bucklers, made likewise of the skins of wild beasts. They used no saddles. Their horses were small and swift, had wooden collars about their necks, and were so much under the command of their riders, that they would follow them like dogs. The habit of these horsemen was not much different from that of the foot above mentioned, they constantly wearing a large tunic of the skins of wild beasts. The Phutæi, of whom the Mauritanians were a branch, were eminent for their shields, and the excellent use they made of them, as we learn from Homer, Xenophon, Herodotus, and Scripture. Nay, Herodotus seems to intimate, that the shield and helmet came from them to the Greeks. 5. Notwithstanding the fertility of their soil, the poorer sort of the Mauritanians never took care to manure the ground, being strangers to the art of husbandry; but roved about the country in a wild savage manner, like the ancient Scythians or Arabes Scenitæ. They had tents, or *mapalia*, so extremely small, that they could scarce breathe in them. Their food was corn, herbage, &c. which they frequently did eat green, without any manner of preparation, being destitute of wine, oil, and all the elegancies as well as many necessaries of life. Their habit was the same both in summer and winter, consisting chiefly of an old tattered, though thick garment, and over it a coarse rough tunic; which answered probably to that of their neighbours the Numidians. Most of them lay every night upon the bare ground; though some of them strewed their garments thereon, not unlike the present African Kabyles and Arabs, who, according to Dr Shaw, use their hykes for a bed and covering in the night. 6. If the most approved reading of Horace may be admitted, the Mauritanians shot poisoned arrows; which clearly intimates, that they had some skill in the art of preparing poisons, and were excellent dartmen. This last observation is countenanced by Herodian and Ælian, who entirely come into it, affirming them to have been in such continual danger of being devoured by wild beasts, that they durst not stir out of their tents or mapalia without their darts. Such perpetual exercise must render them exceedingly skilful in hurling that weapon. 7. The Mauritanians sacrificed human victims to their deities, as the Phœnicians, Carthaginians, &c. did.

The country people were extremely rude and barbarous; but those inhabiting cities must undoubtedly have had at least some smattering in the literature of the several nations they deduced their origin from. That the Mauritanians had some knowledge in naval affairs, seems probable, not only from the intercourse they had with the Phœnicians and Carthaginians, as well as the situation of their country; but likewise from Orpheus, or Onomacritus, who asserts them to have made a settlement at the entrance into Colchis, to which place they came by sea. Magic, sorcery, divination, &c. they appear to have applied themselves to in very early times. Cicero and Pliny say, that Atlas was the inventor of astrology, and the doctrine of the sphere, i. e. he first introduced them into Mauritania. This, according to Diodorus Siculus, gave rise to the fable of Atlas bearing the heavens upon his shoulders. The same author relates that Atlas instructed Hercules in the doctrine of the sphere and astrology, or rather astronomy, who afterwards brought those sciences into Greece.

MAURITIA, the GINKGO, or *Maidenhair Tree*; a genus of plants belonging to the natural order of palmæ. See BOTANY *Index*.

MAURITIUS, or MAURICE, an island of Africa, about 400 miles east of Madagascar, lying in the latitude of 20 and 21 degrees south. It is about 150 miles in circumference. In the beginning of the 16th century it was discovered by the Portuguese, who knowing that Pliny and other ancient writers had mentioned the island of Cerne in these seas, took it for granted that this must be it; and accordingly we find it styled *Cerne* or *Sirne*, in their maps: but, notwithstanding this, they did not think fit to settle it; and indeed their force was so small, in comparison of the vast dominions they grasped, that it was very excusable. However, according to their laudable custom, they put some hogs, goats, and other cattle, upon it, that in case any of their ships either going to the Indies or returning to Portugal should be obliged to touch there, they might meet with refreshments. The Dutch, in the second voyage they made to the East Indies under their admiral James Cornelius Vanneck, came together with five ships on the 15th of September 1568; anchored in a commodious port, to which they gave the name of *Warwick Haven*; and gave a very good account of the place in their journals. Captain Samuel Castleton, in the Pearl, an English East India ship, arrived there on the 27th of March 1612; and taking it to be an island undiscovered before, bestowed upon it the name of *England's Forest*, though others of his crew called it *Pearl Island*; and in the account of their voyage, written by John Tatton the master of the ship, celebrated it as a place very convenient for shipping, either outward or homeward bound, to refresh at. This they sometimes accordingly did, and brought some cargoes of ebony, and rich wood from thence, but without fixing any settlement.

At length, in 1638, the Dutch seated themselves here: and it is highly remarkable, that at the very time they were employed in making their first settlement, the French sent a vessel to take possession of it, who found the Dutch beforehand with them, and refused the assistance of an English Indiaman, wooding and watering in another part of the island, who very frankly offered it, to drive the Dutch from their half settled posts. They continued for some time in quiet

Mauritius. possession of the places they fortified in this island, to which they gave the name of *Mauritius*, in honour of Prince Maurice their stadtholder. But having engaged the French, who were settled on Madagascar, to steal 50 of the natives, and sell them for slaves, for the improvement of the Dutch settlements here, this proved the ruin of both colonies; for the negroes surprised and massacred the French in Madagascar; and the slaves in Mauritius fled into the centre of the island; from whence they so much and so incessantly molested those who had been formerly their masters, that they chose to quit a country where they could no longer remain in any tolerable degree of safety. The East India Company, however, from motives of conveniency, and a very imperfect notion of its value, disapproved this measure, and therefore ordered it to be resettled; which was accordingly done, and three forts erected at the principal havens. Things now went on somewhat better than they did before; but they were still very much disturbed by the revolted negroes in the heart of the isle, whom they could never subdue. One principal use that the company made of this place, was to send thither state prisoners, who, as they were not men of the best morals, quickly corrupted the rest of the inhabitants, and rendered them such a race of outrageous smugglers, the situation of the place concurring with their bad disposition, that, after various ineffectual attempts made to reform them, orders were at length given to abandon Mauritius a second time, which after some delays, were put in execution in the year 1710.

Two years after this, the French took possession of it, and named it the *isle de France*. This name has obtained among themselves, but the Europeans in general continue to call it Mauritius. It lies in S. Lat. 20. 15. E. Long. 6. 15. The inconveniences arising from the want of a port at the island of Bourbon, induced the French to take possession of Mauritius, it having two very good harbours, to fortify which no expence has been spared. That on the north-west is called *Port Louis*, that on the south-east side of the island is called *Port Bourbon*. The trade-wind from the south-east in these latitudes blows all the year round, excepting for a few days at the summer solstice, when it is interrupted by hard gales and hurricanes from the north. The ease with which this wind enables ships to enter the port of Bourbon, caused the French, when they first took possession of this spot, to esteem it the best port in the island; but experience pointing out to them, that the same wind often rendered the passage out of the harbour so difficult, that a ship was sometimes obliged to wait a considerable time before the weather admitted of her putting to sea, this harbour is in a great measure abandoned, and the principal town and seat of government is now fixed at Port Louis, which is nearly in the middle of the north side of the island, and its entrance is through a channel formed by two shoals, which advance abont two miles into the sea. When a ship arrives opposite to this channel, the south-east wind hinders her from entering the port under sail, and she must either warp in with cables or be towed in with boats. The necessity of this operation, joined to the extreme narrowness of the channel, which does not admit of two ships abreast of each other entering at the same time, is one of the best defences the harbour has against an attack by sea; for, from these obstacles, an enemy would find it a matter of the greatest difficulty to force the port; and in addition to this natural strength, they have built two forts and as many batteries, which are mounted with heavy cannon, and entirely command the approach to the harbour, should ships presume to force an entry under sail. This port is capable of containing 100 sail of ships, and is well provided with every requisite for repairing and even building of ships. This port has proved of the greatest advantage to France in the several wars which have been carried on between Great Britain and her; and has proved of great utility to the French East India Company's commerce; for here their ships and crews were sure to meet with all necessary refreshment after a long voyage. The port of Bourbon is also fortified; and an army landed here would find it an extremely difficult task to pass the mountains to the different parts of the island. There are several places between the north-east extremity and Port Louis where boats may land, but all these are defended by batteries; and the country behind them is a continued thicket: The rest of the coast is inaccessible. In the north-eastern quarter is a plain extending about 10 miles from east to west, and in some places five miles inland from the northern coast. All the rest of the island is full of high and steep mountains, lying so near to one another, and the intervals between them so narrow, that, instead of valleys, they rather resemble the beds of torrents; and these are choked with huge fragments of rocks which have fallen from the steep sides of the impending mountains. On the summits of the mountains ice is frequently to be found, and they are covered with forests of ebony and other large trees. The ground they shade produces herbage, shrubs, and plants of various sorts, from the common grass to the strongest thorn, and that in such profusion, that they form a thicket so closely interwoven, that no progress can be made but by means of a hatchet. Notwithstanding these difficulties, plantations have been formed on these mountains, and very considerable progress has been made in the plains; but the productions, although mostly of the same kind, are not only in less quantity, but of an inferior quality to those produced at Bourbon island.

In a course of years, however, the settlement cost so much, and was considered in every light worth so little, that it had been more than once under deliberation, whether, after the example of the Dutch, they should not leave it again to its old negro inhabitants; which sooner or later in all likelihood would have been its fate, if, in 1735, the famous M. de la Bourdonnais had not been sent thither with the title of *governor-general of the French islands*.

He found this isle in the worst state possible, thinly inhabited by a set of lazy people, who equally hated industry and peace, and who were continually flattering this man to his face, and belying him wherever and as far as they durst. He gave himself no trouble about this, having once found the means to make himself obeyed; he saw the vast importance of the island; he conceived that it might be settled to great advantage; and, without so much as expecting the thanks of those for whom he laboured, he began to execute this great design. His first step was to bring over black

Mauritius. black boys from Madagascar, whom he carefully trained up in good principles, and in continual exercise; by which he rendered them so good soldiers, that he very quickly obliged the Marones, or wild negroes, either to submit or to quit the island: he taught the planters to cultivate their lands to advantage; he, by an aqueduct, brought fresh water to the sea side; and whereas they had not so much as a boat at his coming thither, he made a very fine dock, where he not only built sloops and large vessels, but even a ship of the burden of 500 tons. However incredible it may seem, yet it is certainly fact, that in the space of five years he converted this country into a paradise, that had been a mere wilderness for 5000; and this in spite of the inhabitants, and of the company, who being originally prejudiced by them, behaved ill to him at his return. He soon made the cardinal de Fleury, however, sensible of the true state of things; and compelled the company to acknowledge, though they did not reward, his services. He afterwards returned into the Indies, and perfected the work he had begun, and to him it is owing that the isle of France was rendered one of the finest and most important spots upon the globe. Here no coffee is raised; but by the indefatigable industry of M. de Bourdonnais, sugar, indigo, pepper, and cotton (which are not at Bourbon), came to be cultivated with success. Since the departure of that most excellent governor, the plantations have been neglected, and are fallen off; but if a proper spirit of activity was raised among the inhabitants, they might soon be made to resume their flourishing appearance. Mines of iron have been discovered in the mountains near the great plain, in the north-east part of the island; and these mountains affording in great abundance the necessary fuel, forges have been erected: but the iron produced is of a very inferior quality, it being brittle, and only fit for making cannon-balls and bomb-shells. Black cattle, sheep, and goats, are preserved with difficulty; the first generally die before they have been a year in the island, and this occasions frequent importations of them from Madagascar and other parts. Common domestic poultry breed in great plenty; and, with fish and turtle, furnish a great part of the food of the European inhabitants.

The approach to the island is extremely dangerous, it being surrounded with ledges of rocks, and many of them covered by the sea. The shore abounds with coral and shells. This island is said to contain 60 rivers: some are considerable streams, and most of them have their sources from lakes, of which there are several in the middle part of the island. The rivers afford plenty of various kinds of fish, particularly eels. These are of an enormous size, some having been found that were six feet long, and six inches in circumference, and so extremely voracious, that it is dangerous to bathe in those parts of the river where they lie, as they will seize a man without fear, and have strength sufficient to keep him under water till he is drowned. Here is a great variety of birds, and bats as large as a young kitten: the inhabitants esteem them a delicate morsel. The air is both hot and moist, but not unwholesome. The place abounds with insects, which are very troublesome; but there are no serpents. It has been discovered, that off Port Louis the south-east wind generally blows with least strength about sunrise; and it also happens, on four or five days, at intervals, in the course of a month, that early in the morning the wind ceases in the northern part of the island for an hour or two, when a breeze rises, although but faintly, from the north-west; during which, a ship stationed at the entrance of the channel to avail herself of this breeze, may enter the harbour and attack the forts.

Mauritius || Maxentius.

This island, during the period of the French revolution, did not entirely escape from the storm which then agitated the parent country. In the year 1799, a conspiracy was formed, and broke out, for the purpose of resisting the government which had been established under the authority of the republic. It was, however, soon suppressed by the activity of the civil authorities, supported by the majority of the inhabitants.

The population of this island in 1799 amounted to 65,000, viz. 55,000 slaves, and 10,000 whites and mulattoes. The following is a state of the produce of this island in 1800: viz. coffee, 6000 bales, of 100 lbs. French; indigo, 300,000 lbs. from 2s. to 8s. per lb.; cotton, 2000 bales, of 250 lbs.; raw sugar, 20,000,000 lbs.; cloves, 20,000 lbs. The island of Mauritius, as well as the other French islands in the Indian ocean, were taken by the British in 1811; and their possession was confirmed to Britain by the treaty of Paris in 1814.

MAURUA, one of the Society islands in the South sea. It is a small island, entirely surrounded with a ridge of rocks, and without any harbour for shipping. It is inhabited; and its productions are the same with those of the neighbouring islands. A high round hill rises in the middle of it, which may be seen at the distance of 10 or 12 leagues. W. Long. 152. 32. S. Lat. 16. 25.

MAUSOLEUM, a magnificent tomb or sepulchral monument. The word is derived from Mausolus king of Caria, to whom Artemisia his widow erected a most stately monument, esteemed one of the wonders of the world, and called it, from his own name, *Mausoleum.*

St MAWES, a town of Cornwall, in England, seated on the east side of Falmouth haven, in W. Long. 4. 56. N. Lat. 50. 6. Though but a hamlet of the parish of St Just, two miles off, without a minister, or either church, chapel, or meeting-house, it has sent members to parliament ever since 1562, who are returned by its mayor or portreve. It consists but of one street, under a hill, and fronting the sea, and its inhabitants subsist purely by fishing. K. Henry VIII. built a castle here, opposite to Pendennis, for the better security of Falmouth haven. It has a governor, a deputy, and two gunners, with a platform of guns. Here is a fair the Friday after St Luke's day.

MAXENTIUS, Marcus Aurelius Valerius, a son of the emperor Maximianus Hercules, was, by the voluntary abdication of Dioclesian, and of his father, raised to the empire A. D. 306. He afterwards incited his father to reassume his imperial authority; and in a perfidious manner destroyed Severus, who had delivered himself into his hands, and relied upon his honour for the safety of his life. His victories and successes were impeded by Galerius Maximianus, who opposed him with a powerful force. The defeat and

and voluntary death of Galerius soon restored peace to Italy; and Maxentius passed into Africa, where he rendered himself odious by his cruelty and oppression. He soon after returned to Rome, and was informed that Constantine was come to dethrone him. He gave his adversary battle near Rome, and, after he had lost the victory, he fled back to the city. The bridge over which he crossed the Tiber was in a decayed situation, and he fell into the river, and was drowned, A. D. 312. The cowardice and luxuries of Maxentius were as conspicuous as his cruelties. He oppressed his subjects with heavy taxes, to gratify the cravings of his pleasures, or the avarice of his favourites. He was debauched in his manners, and neither virtue nor innocence were safe whenever he was inclined to voluptuous pursuits. His body was deformed and unwieldy. To visit a pleasure ground, or to exercise himself under a marble portico, or walk on a shady terrace, was to him a Herculean labour, which required the greatest exertions of strength and resolution.

MAXILLA, the JAW. See ANATOMY, N° 20—26.

MAXIM, an established proposition or principle: in which sense it denotes much the same with axiom.

MAXIMILIAN I. emperor of Germany, signalized himself against the French while he was king of the Romans, and after he was emperor entered into the army of Henry VIII. of England as a volunteer against that nation: he was a protector of learned men, and abolished an iniquitous tribunal, styled *Judicium occultum Westphaliæ;* he composed some poems, and the memoirs of his own life. He died in 1519, aged 60.

MAXIMUM, in *Mathematics*, denotes the greatest quantity attainable in any given case.

If a quantity conceived to be generated by motion increases or decreases till it arrives at a certain magnitude or position, and then, on the contrary, grows greater or lesser, and it be required to determine the said magnitude or position, the question is called a *problem de maximis et minimis*.

MAXIMUS, a celebrated Cynic philosopher, and magician, of Ephesus. He instructed the emperor Julian in magic; and, according to the opinion of some historians, it was in the conversation and company of Maximus that the apostasy of Julian originated. The emperor not only visited the philosopher, but he even submitted his writings to his inspection and censure. Maximus refused to live in the court of Julian; and the emperor, not dissatisfied with the refusal, appointed him high pontiff in the province of Lydia, an office which he discharged with the greatest moderation and justice. When Julian went into the east, the philosopher promised him success, and even said that his conquests would be more numerous and extensive than those of the son of Philip. He persuaded his imperial pupil, that, according to the doctrine of metempsychosis, his body was animated by the soul which once animated the hero whose greatness and victories he was going to eclipse. After the death of Julian, Maximus was almost sacrificed to the fury of the soldiers; but the interposition of his friends saved his life, and he retired to Constantinople. He was soon after accused of magical practices, before the emperor Valens, and beheaded at Ephesus, A. D. 366. He wrote some philosophical and rhetorical treatises, some of which were dedicated to Julian. They are all now lost.

MAXIMUS *of Tyre*, a Platonic philosopher, went to Rome in 146, and acquired such reputation there, that the emperor Marcus Aurelius became his scholar, and gave him frequent proofs of his esteem. This philosopher is thought to have lived till the reign of the emperor Commodus. There are still extant 41 of his dissertations; a good edition of which was printed by Daniel Heinsius, in 1624, in Greek and Latin, with notes.

MAXIMUS MARIUS. See *MARIUS*.

MAY, the fifth month in the year, reckoning from our first, or January; and the third, counting the year to begin with March, as the Romans anciently did. It was called Maius by Romulus, in respect to the senators and nobles of his city, who were named *majores;* as the following month was called *Junius*, in honour of the youth of Rome, *in honorem juniorum*, who served him in the war; though some will have it to have been thus called from *Maia*, the mother of Mercury, to whom they offered sacrifice on the first day of it; and Papius derives it from *Madius, eo quod tunc terra madeat*. In this month the sun enters Gemini, and the plants of the earth in general begin to flower. —The month of May has ever been esteemed favourable to love; and yet the ancients, as well as many of the moderns, look on it as an unhappy month for marriage. The original reason may perhaps be referred to the feast of the Lemures, which was held in it. Ovid alludes to this in the fifth of his Fasti, when he says,

> *Nec viduæ tædis eadem, nec virginis apta*
> *Tempora; quæ nupsit, non diuturna fuit;*
> *Hac quoque de causa, si te proverbia tangunt,*
> *Mense malum* Maio *nubere vulgus ait.*

MAY-dew. See DEW.

MAY-duke, a species of cherry. See PRUNUS, BOTANY *Index*.

MAY, *Isle of*, a small island at the mouth of the frith of Forth, in Scotland, about a mile and a half in circumference, and seven miles from the coast of Fife, almost opposite to the rock called the *Bass*. It formerly belonged to the priory of Pittenweem: and was dedicated to St Adrian, supposed to have been martyred in this place by the Danes; and hither, in times of Popish superstition, barren women used to come and worship at his shrine, in hopes of being cured of their sterility. Here is a tower and lighthouse built by Mr Cunningham of Barns, to whom King Charles I. granted the island in fee, with power to exact twopence per ton from every ship that passes, for the maintenance of a lighthouse. In the middle of it there is a fresh-water spring, and a small lake.—The soil produces pasturage for 100 sheep and 20 black cattle. On the west side the steep rocks render it inaccessible; but to the east there are four landing places and good riding. It was here that the French squadron, having the chevalier de St George on board, anchored in the year 1708, when the vigilance of Sir George Byng obliged him to relinquish his design, and bear away for Dunkirk. The shores all round the island abound with fish, and the cliffs with water fowl.

MAY, *Thomas*, an eminent English poet and historian in the 17th century, was born of an ancient but decayed family in Sussex, educated at Cambridge, and afterwards removed to London. While he resided at court, he wrote the five plays now extant under his name. In 1622, he published a translation of Virgil's Georgics, with annotations; and in 1635 a poem on King Edward III. and a translation of Lucan's Pharsalia; which poem he continued down to the death of Julius Cæsar, both in Latin and English verse. Upon the breaking out of the civil wars he adhered to the parliament; and in 1647, he published, "The history of the parliament of England, which began November the third, MDCXL. With a short and accessary view of some precedent years." In 1649, he published, *Historiæ Parliamenti Angliæ Breviarium*, in three parts; which he afterwards translated into English. He wrote the History of Henry II. in English verse. He died in 1642. He went well to rest over night, after a cheerful bottle as usual, and died in his sleep before morning: upon which his death was imputed to his tying his nightcap too close under his fat cheeks and chin, which caused his suffocation; but the facetious Andrew Marvel has written a poem of 100 lines, to make him a martyr of Bacchus, and die by the force of good wine. He was interred near Camden in Westminster Abbey; which caused Dr Fuller to say, that "if he were a biassed and partial writer, yet he lieth buried near a good and true historian indeed." Soon after the Restoration, his body, with those of several others, was dug up, and buried in a pit in St Margaret's churchyard; and his monument, which was erected by the appointment of parliament, was taken down and thrown aside.

MAYER, TOBIAS, one of the greatest astronomers and mechanics the 18th century produced, was born at Maspach, in the duchy of Wirtemberg, 1723. He taught himself mathematics, and at the age of fourteen designed machines and instruments with the greatest dexterity and justness. These pursuits did not hinder him from cultivating the belles lettres. He acquired the Latin tongue, and wrote it with elegance. In 1750, the university of Gottingen chose him for their mathematical professor; and every year of his short life was thenceforward marked with some considerable discoveries in geometry and astronomy. He published several works in this way, which are all reckoned excellent; and some are inserted in the second volume of the "Memoirs of the university of Gottingen." His labours seem to have exhausted him; for he died worn out in 1762.

MAYERNE, SIR THEODORE DE, baron of Aulbone, was the son of Lewis de Mayerne, the celebrated author of the General History of Spain, and of the *Monarchie aristo-democratique*, dedicated to the states-general. He was born in 1573, and had for his godfather Theodore Beza. He studied physic at Montpelier, and was made physician in ordinary to Henry IV. who promised to do great things for him, provided he would change his religion. James I. of England invited him over, and made him first physician to himself and his queen, in which office he served the whole royal family to the time of his death in 1655. His works were printed at London in 1700, and make a large folio, divided into two books; the first containing his *Consilia, Epistolæ, et Observationes*; the second his *Pharmacopœia variæque medicamentorum formulæ*.

MAYHEM. See MAIM.

MAYNE, JASPER, an eminent English poet and divine in the 17th century, who was bred at Oxford, and entered into holy orders. While his majesty resided at Oxford, he was one of the divines appointed to preach before him. He published in 1647 a piece entitled ΟΧΛΟΜΑΧΙΑ, or *The people's war examined according to the principles of reason and scripture, by Jasper Mayne.* In 1648 he was deprived of his studentship at Christ church, and two livings he had; but was restored with the king, who made him his chaplain and archdeacon of Chichester; all which he held till he died. Dr Mayne was held in very high esteem both for his natural parts and his acquired accomplishments. He was an orthodox preacher, and a man of severe virtue and exemplary behaviour; yet of a ready and facetious wit, and a very singular turn of humour. From some stories that are related of him, he seems to have borne some degree of resemblance in his manner to the celebrated Dr Swift; but if he did not possess those very brilliant parts that distinguished the Dean, he probably was less subject to that capricious and those unaccountable whimsies which at times so greatly eclipsed the abilities of the latter. Yet there is one anecdote related of him, which, although it reflects no great honour on his memory, as it seems to carry some degree of cruelty with it, yet it is a strong mark of his resemblance to the Dean, and a proof that his propensity for drollery and joke did not quit him even in his latest moments. The story is this: The Doctor had an old servant, who had lived with him some years, to whom he had bequeathed an old trunk, in which he told him he would find *something that would make him drink after his death.* The servant, full of expectation that his master, under this familiar expression, had left him somewhat that would be a reward for the assiduity of his past services, as soon as decency would permit, flew to the trunk; when, behold, to his great disappointment, the boasted legacy proved to be a red herring. The doctor, however, bequeathed many legacies by will to pious uses; particularly 50 pounds towards the rebuilding of St Paul's cathedral, and 200 pounds to be distributed to the poor of the parishes of Cassington and Pyrton, near Wattington, of both which places he had been vicar. In his younger years he had an attachment to poetry; and wrote two plays, the latter of which may be seen in the tenth volume of Dodsley's Collection, viz. 1. Amorous war, a tragi-comedy. 2. The city-match, a comedy. He published a poem upon the naval victory by the duke of York over the Dutch, printed in 1665. He also translated into English from the Greek, part of Lucian's Dialogues.

MAYNOOTH, or MANOOTH, a post town in the county of Kildare, in Ireland, 12 miles from Dublin. At this place there is a catholic college, established by the

the Irish parliament in 1795. Young men destined for the catholic church had formerly gone to the continent for their education. This had now become nearly impossible, in consequence of the war with France and Spain; and for this reason, as well as to prevent those foreign attachments which grow out of a foreign education, it was thought prudent to provide the means of domestic instruction for the catholics. They had only petitioned for leave to establish a seminary; but the parliament also granted 8000l. per annum for its support, which was afterwards enlarged to 13,000l.; but has since been diminished. There were in 1808, eight professorships and three lectureships; and there was accommodation for 200 students, to whom the establishment afforded commons and instruction.

MAYNWARING, Arthur, an eminent political writer in the beginning of the 18th century, staid several years at Oxford, and then went to Cheshire, where he lived some time with his uncle Mr Francis Cholmondeley, a very honest gentleman, but extremely averse to the government of King William III. to whom he refused the oaths. Here he prosecuted his studies in polite literature with great vigour; and coming up to London, applied to the study of the law. He was hitherto very zealous in anti-revolutional principles, and wrote several pieces in favour of King James II.; but upon being introduced to the duke of Somerset and the earls of Dorset and Burlington, began to entertain very different notions in politics. His father left him an estate of near 800l. a-year, but so encumbered, that the interest money amounted to almost as much as the revenue. Upon the conclusion of the peace he went to Paris, where he became acquainted with Mr Boileau. After his return he was made one of the commissioners of the customs, in which post he distinguished himself by his skill and industry. He was a member of the Kit-cat club, and was looked upon as one of the chief supports of it by his pleasantry and wit. In the beginning of Queen Anne's reign, the lord treasurer Godolphin engaged Mr Donne to quit the office of auditor of the imprests, and made Maynwaring a present of a patent for that office worth about 2000l. a-year in a time of business. He had a considerable share in the Medley, and was author of several other pieces. The Examiner, his antagonist in politics, allowed that he wrote with tolerable spirit, and in a masterly style. Sir Richard Steele dedicated the first volume of the Tatler to him.

MAYO, one of the Cape de Verd islands, lying in the Atlantic ocean, near 300 miles from Cape Verd in Africa, about 17 miles in circumference. The soil in general is very barren, and water scarce: however, they have some corn, yams, potatoes, and plantains, with plenty of beeves, goats, and asses. What trees there are, grow on the sides of the hills, and they have some figs and water melons. The sea round about the island abounds with fish. The chief commodity is salt, with which many English ships are loaded in the summer time. The principal town is Pinosa, inhabited by negroes, who speak the Portuguese language, and are stout, lusty, and fleshy. They are not above 200 in number, and many of them go quite naked. W. Long. 23. 5. N. Lat. 15. 10.

Mayo, a county of Ireland, in the province of Con-

naught, having Sligo and the sea on the north; Roscommon on the south, Leitrim and Roscommon on the east, and the Atlantic ocean on the west. It contains 724,640 Irish plantation acres, 68 parishes, and 140,000 inhabitants. It gives title of earl to the family of Bourke. This county takes its name from an ancient city, built in 664; the ruins of the cathedral, and some traces of the stone walls which encompassed the city, yet remain on the plains of Mayo. It was a university, founded for the education of such of the Saxon youths as were converted to the Christian faith: it was situated a little to the south of Lough Conn; and is to this day frequently called *Mayo of the Saxons*, being celebrated for giving education to Alfred the Great, king of England. As this town has gone to decay, Balinroke is reckoned the chief town. The county by the sea is mountainous; but inland has good pastures, lakes, and rivers. It is about 62 miles long, and 52 broad. Castlebar is the assizes town.—Mayo was formerly a bishop's see, which is now united to Tuam.

MAYOR, the chief magistrate of a city or town, chosen annually out of the aldermen. The word, anciently wrote *meyr*, comes from the British *miret*, i. e. *custodire*, or from the old English *maier*, viz. *potestas*, and not from the Latin *major*. King Richard I. in 1189, changed the bailiff of London into a mayor, and from that example King John made the bailiff of King's Lynn a mayor anno 1204: Though the famous city of Norwich obtained not this title for its chief magistrates till the seventh year of King Henry V. anno 1419; since which there are few towns of note but have had a mayor appointed for government.

Mayors of corporations are justices of peace *pro tempore*, and are mentioned in several statutes; but no person shall bear any office of magistracy concerning the government of any town, corporation, &c. who hath not received the sacrament according to the church of England within one year before his election, and who shall not take the oaths of supremacy, &c.

If any person intrudes into the office of mayor, a *quo warranto* lies against him, upon which he shall not only be ousted, but fined. And no mayor, or person holding an annual office in a corporation for one year, is to be elected into the same office for the next; in this case, persons obstructing the choice of a successor are subject to 100l. penalty. Where the mayor of a corporation is not chosen on the day appointed by charter, the next officer in place shall the day after hold a court and elect one; and if there be a default or omission that way, the electors may be compelled to choose a mayor, by a writ of mandamus out of the king's bench. Mayors, or other magistrates of a corporation, who shall voluntarily absent themselves on the day of election, are liable to be imprisoned, and disqualified from holding any office in the corporation.

Mayor's Courts. To the lord mayor and city of London belong several courts of judicature. The highest and most ancient is that called the *hustings*, destined to secure the laws, rights, franchises, and customs of the city. The second is a court of *request*, or of *conscience;* of which before. The third is the court of the lord mayor and aldermen, where also the sheriffs sit;

sit; to which may be added two courts of sheriffs, and the court of the city orphans, whereof the lord mayor and aldermen have the custody. Also the court of common council, which is a court or assembly, wherein are made all by-laws which bind the citizens of London. It consists, like the parliament, of two houses: an upper, consisting of the lord mayor and aldermen; and a lower, of a number of common council men, chosen by the several wards as representatives of the body of the citizens. In the court of common council are made laws for the advancement of trade, and committees yearly appointed, &c. But acts made by them are to have the assent of the lord mayor and aldermen by stat. 11. Geo. I. Also the chamberlain's court, where every thing relating to the rents and revenues of the city, as also the affairs of servants, &c. are transacted. Lastly, to the lord mayor belong the courts of coroner and of eschcator; another court for the conservation of the river Thames; another of gaol delivery, held usually eight times a year, at the Old Bailey, for the trial of criminals, whereof the lord mayor is himself the chief judge. There are other courts called *wardmotes* or meetings of the wards; and courts of halymote or assemblies of the several guilds and fraternities.

MAZA, among the Athenians, was a sort of cake made of flour boiled with water and oil, and set as the common fare, before such as were entertained at the public expence in the common hall or *Prytaneum*.

MAZAGAN, a strong place of Africa in the kingdom of Morocco, and on the frontiers of the province of Duguela. It was fortified by the Portuguese, and besieged by the king of Morocco with 200,000 men in 1562, but to no purpose. It is situated near the sea. W. Long. 8. 15. N. Lat. 33. 12.

MAZARA, an ancient town of Sicily, and capital of a considerable valley of the same name, which is very fertile, and watered with several rivers. The town is a bishop's see, and has a good harbour; is seated on the sea coast, in E. Long. 12. 30. N. Lat. 37. 53.

MAZARINE, Julius a famous cardinal and prime minister of France, was born at Piscina in the province of Abruzzo, in Naples, in 1602. After having finished his studies in Italy and Spain, he entered into the service of Cardinal Sachetts, and became well skilled in politics, and in the interests of the princes at war in Italy; by which means he was enabled to bring affairs to an accommodation, and the peace of Queiras was shortly concluded. Cardinal Richlieu being taken with his conduct, did from thenceforward highly esteem him; as did also Cardinal Antonio, and Louis XIII. who procured him a cardinal's hat in 1641. Richlieu made him one of the executors of his will; and during the minority of Louis XIV. he had the charge of affairs. At last he became the envy of the nobility, which occasioned a civil war; whereupon Mazarine was forced to retire, a price was set on his head, and his library sold. Notwithstanding, he afterwards returned to the court in more glory than ever; concluded a peace with Spain, and a marriage treaty betwixt the king and the infanta. This treaty of peace passes for the masterpiece of Cardinal de Mazarine's politics, and procured him the French king's most intimate confidence: but at last his continual application to business threw him into a disease, of which he died at Vincennes in 1661.—Cardinal Mazarine was of a mild and affable temper. One of his greatest talents was his knowing mankind, and his being able to adapt himself, and to assume a character conformable to the circumstances of affairs. He possessed at one and the same time the bishopric of Metz, and the abbeys of St Arnauld, St Clement, and St Vincent, in the same city; that of St Dennis, Clugny, and Victor, of Marseilles; of St Michel at Soissons, and a great number of others. He founded Mazarine college at Paris; which is also called the *college of the four nations*. There has been published a collection of his letters, the most copious edition of which is that of 1745, in 2 vols. duodecimo.

MAZZUOLI. See Parmigiano.

MEAD, a wholesome, agreeable liquor, prepared with honey and water.

One of the best methods of preparing mead is as follows: Into twelve gallons of water put the whites of six eggs; mixing these well together, and to the mixture adding twenty pounds of honey. Let the liquor boil an hour; and when boiled, add cinnamon, ginger, cloves, mace, and rosemary. As soon as it is cold, put a spoonful of yest to it, and tun it up, keeping the vessel filled as it works; when it has done working, stop it up close; and, when fine, bottle it off for use.

The author of the Dictionary of Chemistry directs to choose the whitest, purest, and best tasted honey, and to put it into a kettle with more than its weight of water: a part of this liquor must be evaporated by boiling, and the liquor scummed, till its consistence is such, that a fresh egg shall be supported on its surface without sinking more than half its thickness into the liquor; then the liquor is to be strained and poured through a funnel into a barrel; this barrel, which ought to be nearly full, must be exposed to a heat as equable as possible, from 20 to 27 or 28 degrees of Mr Reaumur's thermometer, taking care that the bunghole be slightly covered, but not closed. The phenomena of the spirituous fermentation will appear in this liquor, and will subsist during two or three months, according to the degree of heat; after which they will diminish and cease. During this fermentation, the barrel must be filled up occasionally with more of the same kind of liquor of honey, some of which ought to be kept apart, on purpose to replace the liquor which flows out of the barrel in froth. When the fermentation ceases, and the liquor has become very vinous, the barrel is then to be put into a cellar, and well closed; a year afterwards the mead will be fit to be put into bottles. Mead is a liquor of very ancient use in Britain. See Feast.

Mead, *Dr Richard*, a celebrated English physician, was born at Stepney near London, where his father, the Reverend Mr Matthew Mead, had been one of the two ministers of that parish; but in 1662 was ejected for nonconformity, but continued to preach at Stepney till his death. As Mr Mead had a handsome fortune, he bestowed a liberal education upon 13 children, of whom Richard was the eleventh; and for that purpose kept a private tutor in his house,

who

Mead. who taught him the Latin tongue. At 16 years of age Richard was sent to Utrecht, where he studied three years under the famous Grævius; and then choosing the profession of physic, he went to Leyden, where he attended the lectures of the famous Pitcairn on the theory and practice of medicine, and Herman's botanical courses. Having also spent three years in these studies, he went with his brother and two other gentlemen to visit Italy, and at Padua took his degree of doctor of philosophy and physic in 1695. Afterwards he spent some time at Naples and at Rome; and returning home the next year, settled at Stepney, where he married, and practised physic with a success that laid the foundation of his future greatness.

In 1703, Dr Mead having communicated to the Royal Society an analysis of Dr Bonomo's discoveries relating to the cutaneous worms that generate the itch, which they inserted in the Philosophical Transactions; this, with his account of poisons, procured him a place in the Royal Society, of which Sir Isaac Newton was then president. The same year he was elected physician of St Thomas's hospital, and was also employed by the surgeons to read anatomical lectures in their hall, which obliged him to remove into the city. In 1707 his Paduan diploma for doctor of physic was confirmed by the university of Oxford; and being patronized by Dr Radcliffe, on the death of that famous physician he succeeded him in his house at Bloomsbury-square, and in the greatest part of his business. In 1727 he was made physician to King George II. whom he had also served in that capacity while he was prince of Wales; and he had afterwards the pleasure of seeing his two sons-in-law, Dr Nichols and Dr Wilmot, his coadjutors in that eminent station.

Dr Mead was not more to be admired for the qualities of the head than he was to be loved for those of his heart. Though he was himself a hearty whig, yet, uninfluenced by party principles, he was a friend to all men of merit, by whatever denomination they might happen to be distinguished. Thus he was intimate with Garth, with Arbuthnot, and with Freind; and long kept up a constant correspondence with the great Boerhaave, who had been his fellow student at Leyden: they communicated to each other their observations and projects, and never loved each other the less for being of different sentiments. In the mean time, intent as Dr Mead was on the duties of his profession, he had a greatness of mind that extended itself to all kinds of literature, which he spared neither pains nor money to promote. He caused the beautiful and splendid edition of Thuanus's history to be published in 1713, in seven volumes folio: and by his interposition and assiduity, Mr Sutton's invention of drawing foul air from ships and other close places was carried into execution, and all the ships in his majesty's navy provided with this useful machine. Nothing pleased him more than to call hidden talents into light; to give encouragement to the greatest projects, and to see them executed under his own eye. During almost half a century he was at the head of his business, which brought him one year about seven thousand pounds, and for several years between five and six thousand; yet clergymen, and in general all men of learning, were welcome to his advice. His library consisted of 10,000 volumes, of which his Latin, Greek, and oriental manuscripts, made no inconsiderable part. He had a gallery for his pictures and antiquities, which cost him great sums. His reputation, not only as a physician, but as a scholar, was so universally established, that he corresponded with all the principal literati in Europe: even the king of Naples sent to desire a complete collection of his works; and in return made him a present of the two first volumes of Signior Bajardi, which may be considered as an introduction to the collection of the antiquities of Herculaneum. At the same time that prince invited him to his palace, that he might have an opportunity of showing him those valuable monuments of antiquity; and nothing but his great age prevented his undertaking a journey so suited to his taste. No foreigner of learning ever came to London without being introduced to Dr Mead; and on these occasions his table was always open, and the magnificence of princes was united with the pleasures of philosophers. It was principally to him that the several counties of England and our colonies abroad applied for the choice of their physicians, and he was likewise consulted by foreign physicians from Russia, Prussia, Denmark, &c. He wrote, besides the above works, 1. A Treatise on the Scurvy. 2. *De variolis et morbillis dissertatio.* 3. *Medica sacra: sive de Morbis insignioribus, qui in Bibliis memorantur, Commentarius.* 4. *Monita et Præcepta medica.* 5. A Discourse concerning pestilential contagion, and the methods to be used to prevent it. The works he wrote and published in Latin were translated into English, under the Doctor's inspection, by Thomas Stack, M. D. and F. R. S. This great physician, naturalist, and antiquarian, died on the 16th of February 1754.

Mead ‖ Meal.

MEADOW, in its general signification, means pasture or grass lands, annually mown for hay: but it is more particularly applied to lands that are so low as to be too moist for cattle to graze upon them in winter without spoiling the sward. For the management and watering of meadows, see AGRICULTURE, p. 435.

MEAL, the flour of grain. The meal or flour of Britain is the finest and whitest in the world. The French is usually browner, and the German browner than that. Our flour keeps well with us; but in carrying abroad it often contracts damp, and becomes bad. All flour is subject to breed worms; these are white in the white flour, and brown in that which is brown; they are therefore not always distinguishable to the eye; but when the flour feels damp, and smells rank and musty, it may be conjectured that they are there in great abundance.

The colour and the weight are the two things which denote the value of meal or flour; the whiter and the heavier it is, other things being alike, the better it always is. Pliny mentions these two characters as the marks of good flour; and tells us, that Italy in his time produced the finest in the world. This country indeed was famous before his time for this produce; and the Greeks have celebrated it; and Sophocles in particular says, that no flour is so white or so good as that of Italy. The corn of this country has, however, lost much of its reputation since that time;

Meal.

time; and the reason of this seems to be, that the whole country being full of sulphur, alum, vitriol, marcasites, and bitumens, the air may have in time affected them so far as to make them diffuse themselves through the earth, and render it less fit for vegetation; and the taking fire of some of these inflammable minerals, as has sometimes happened, is alone sufficient to alter the nature of all the land about the places where they are.

The flour of Britain, though it pleases by its whiteness, yet wants some of the other qualities valuable in flour; the bread that is made of it is brittle and does not hold together, but after keeping a few days becomes hard and dry as if made of chalk, and is full of cracks in all parts; and this must be a great disadvantage in it when intended for the service of an army, or the like occasions, where there is no baking every day, but the bread of one making must necessarily be kept a long time.

The flour of Picardy is very like that of Britain; and after it has been kept some time, is found improper for making into paste or dough. The French are forced either to use it immediately on the grinding, or else to mix it with an equal quantity of the flour of Brittany, which is coarser, but more unctuous and fatty; but neither of these kinds of flour keep well.

The flour of almost any country will do for the home consumption of the place, as it may be always fresh ground; but the great care to be used in selecting it, is in order to the sending it abroad, or furnishing ships for their own use. The saline humidity of the sea air rusts metals, and fouls every thing on board, if great care be not taken in the preserving them. This also makes the flour damp and mouldy, and is often the occasion of its breeding insects, and being wholly spoiled.

The flour of some places is constantly found to keep better at sea than that of others; and when that is once found out, the whole caution needs only be to carry the flour of those places. Thus the French find that the flour of Poitou, Normandy, and Guienne, all bear the sea carriage extremely well; and they make a considerable advantage by carrying them to their American colonies.

The choice of flour for exportation being thus made, the next care is to preserve it in the ships; the keeping it dry is the grand consideration in regard to this; the barrels in which it is put up ought to be made of dry and well seasoned oak, and not to be larger than to hold two hundred weight at the most. If the wood of the barrels have any sap remaining in it, it will moisten and spoil the flour; and no wood is so proper as oak for this purpose, or for making the bins and other vessels for keeping flour in at home, since when once well dried and seasoned it will not contract humidity afterwards. The beech wood, of which some make their bins for flour, is never thoroughly dry, but always retains some sap. The fir will give the flour a taste of turpentine; and the ash is always subject to be eaten by worms. The oak is preferable, because of its being free from these faults; and when the several kinds of wood have been examined in a proper manner, there may be others found as fit, or possibly more so, than this for the purpose. The great test is their having more or less sap. See FLOUR and WOOD.

Mean || Measure.

MEAN, in general, denotes the middle between two extremes: thus we say the mean distance, mean proportion, &c.

MEAN, Arithmetical, is half the sum of the two extremes, as 4 is the arithmetical mean between 2 and 6; for $\frac{2+6}{2}=4$.

MEAN, Geometrical, is the square root of the rectangle, or product of the two extremes: thus,

$$\sqrt{1\times 9}={}^{2}\sqrt{9}=3.$$

To find two mean proportionals between two extremes: multiply each extreme by the square of the other, then extract the cube root out of each product, and the two roots will be the mean proportionals required.

Required two proportionals between 2 and 16,

$\overline{2\times 2}\times 16=64$, and ${}^{3}\sqrt{64}=4$. Again, ${}^{3}\sqrt{2\times 16^{2}}={}^{3}\sqrt{512}=8$. 4 and 8 therefore are the two proportionals sought.

MEARNSSHIRE, a county of Scotland. See KINCARDINESHIRE.

MEASLES, a cutaneous disease attended with a fever, in which there is an appearance of eruptions that do not tend to a suppuration. See MEDICINE *Index*.

MEASURE *of an angle*, is an arch described from the vertex in any place between its legs. Hence angles are distinguished by the ratio of the arches, described from the vertex between the legs to the peripheries. Angles then are distinguished by those arches; and the arches are distinguished by their ratio to the periphery. Thus an angle is said to be so many degrees as there are in the said arch.

MEASURE of a solid, is a cube whose side is an inch, a foot, or a yard, or any other determinate length. In geometry it is a cubic perch, divided into cubic feet, digits, &c.

MEASURE of velocity, in *Mechanics*, is the space passed over by a moving body in a given time. To measure a velocity, therefore, the space must be divided into as many equal parts as the time is conceived to be divided into; the quantity of space answering to such a part of time is the measure of the velocity.

MEASURE, in *Geometry*, denotes any quantity assumed as one, or unity, to which the ratio of the other homogeneous or similar quantities is expressed.

MEASURE, in a legal and commercial sense, denotes a certain quantity or proportion of any thing bought, sold, valued, or the like.

It is necessary, for the convenience of commerce, that an uniformity should be observed in weights and measures, and regulated by proper standards. A foot-rule may be used as a standard for measures of length, a bushel for measures of capacity, and a pound for weights. There should be only one authentic standard of each kind, formed of the most durable materials, and kept with all possible care. A sufficient number of copies, exactly corresponding to the principal standard, may be distributed for adjusting the weights and measures that are made for common use. There are several standards of this kind both in England

Measure. England and Scotland. See the article *Weights and Measures*.

If any one of the standards above mentioned be justly preserved, it will serve as a foundation for the others, by which they may be corrected if inaccurate, or restored if entirely lost. For instance, if we have a standard foot, we can easily obtain an inch, and can make a box which shall contain a cubical inch, and may serve as a standard for measures of capacity. If it be known that a pint contains 100 cubical inches, we may make a vessel five inches square, and four inches deep, which will contain a pint. If the standard be required in any other form, we may fill this vessel with water, and regulate another to contain an equal quantity. Standards for weights may be obtained from the same foundation; for if we know how many inches of water it takes to weigh a pound, we have only to measure that quantity, and the weight which balances it may be assumed as the standard of a pound.

Again, If the standard of a pound be given, the measure of an inch may be obtained from it; for we may weigh a cubical inch of water, and pour it into a regular vessel; and having noticed how far it is filled, we may make another vessel of like capacity in the form of a cube. The side of this vessel may be assumed as the standard for an inch; and standards for a foot, a pint, or a bushel, may be obtained from it. Water is the most proper substance for regulating standards; for all other bodies differ in weight from others of the same kind; whereas it is found by experience that spring and river water, rain, and melted snow, and all other kinds, have the same weight; and this uniformly holds in all countries when the water is pure, alike warm, and free from salt and minerals.

Thus, any one standard is sufficient for restoring all the rest. It may further be desired to hit on some expedient, if possible, for restoring the standards, in case that all of them should ever fall into disorder, or should be forgotten, through the length of time, and the vicissitudes of human affairs. This seems difficult, as no words can convey a precise idea of a foot-rule, or a pound weight. Measures, assumed from the dimensions of the human body, as a foot, a hand-breadth, or a pace, must nearly be the same in all ages, unless the size of the human race undergo some change; and therefore, if we know how many square feet a Roman acre contained, we may form some judgment of the nature of the law which restricted the property of a Roman citizen to seven acres; and this is sufficient to render history intelligible; but it is too inaccurate to regulate measures for commercial purposes. The same may be said of standards, deduced from the measure of a barley-corn, or the weight of a grain of wheat. If the distance of two mountains be accurately measured and recorded, the nature of the measure used will be preserved in a more permanent manner than by any standard; for if ever that measure fall into disuse, and another be substituted in its place, the distance may be measured again, and the proportion of the standards may be ascertained by comparing the new and ancient distances.

But the most accurate and unchangeable manner of establishing standards is, by comparing them with the length of pendulums. The longer a pendulum is, it vibrates the slower; and it must have one precise length in order to vibrate in a second. The slightest difference in length will occasion a difference in the time; which will become abundantly sensible after a number of vibrations, and will be easily observed if the pendulum be applied to regulate the motion of a clock. The length of a pendulum which vibrates seconds in London is about $39\frac{1}{8}$ inches, is constantly the same at the same place, but it varies a little with the latitude of the place, being shorter as the latitude is less. Therefore, though all standards of weights and measures were lost, the length of a second pendulum might be found by repeated trials: and if the pendulum be properly divided, the just measure of an inch will be obtained; and from this all other standards may be restored. See *Whitehurst on Invariable Measures*.

Measures are various, according to the various kinds and dimensions of the things measured.—Hence arise lineal or longitudinal measures, for lines or lengths; square measures, for areas or superfices; and solid or cubic measures, for bodies and their capacities; all which again are very different in different countries and in different ages, and even many of them for different commodities. Whence arise other divisions of ancient and modern measures, domestic and foreign ones, dry measures, liquid measures, &c.

I. *Long Measures, or Measures of Application.*

1.] The *English* and *Scotch* Standards.

The English lineal standard is the yard, containing 3 English feet; equal to 3 Paris feet 1 inch and $\frac{3}{10}$ of an inch, or $\frac{7}{9}$ of a Paris ell. The use of this measure was established by Henry I. of England, and the standard taken from the length of his own arm. It is divided into 36 inches, and each inch is supposed equal to 3 barleycorns. When used for measuring cloth, it is divided into four quarters, and each quarter subdivided into 4 nails. The English ell is equal to a yard and a quarter, or 45 inches, and is used in measuring linens imported from Germany and the Low Countries.

The Scots *elwand* was established by King David I. and divided into 37 inches. The standard is kept in the council chamber of Edinburgh, and being compared with the English yard, is found to measure $37\frac{1}{5}$ inches; and therefore the Scots inch and foot are larger than the English, in the proportion of 180 to 185; but this difference being so inconsiderable, is seldom attended to in practice. The Scots ell, though forbidden by law, is still used for measuring some coarse commodities, and is the foundation of the land measure of Scotland.

Itinerary measure is the same both in England and Scotland. The length of the chain is four poles, or 22 yards; 80 chains make a mile. The old Scots computed miles were generally about a mile and a half each.

The reel for yarn is $2\frac{1}{2}$ yards, or 10 quarters, in circuit; 120 threads make a cut, 12 cuts make a hasp or hank, and 4 hanks make a spindle.

2.] The *French* standard was formerly the aune or ell, containing 3 Paris feet 7 inches 8 lines, or 1 yard $\frac{2}{7}$ English; the Paris foot royal exceeding the English by $\frac{68}{1000}$ parts, as in one of the following tables. This ell

Measure.

ell is divided two ways; viz. into halves, thirds, sixths, and twelfths; and into quarters, half-quarters, and sixteenths.

The French, however, have also formed an entirely new system of weights and measures, according to the following table.

Proportions of the measures of each species to its principal measure or unity.	First part of the name which indicates the proportion to the principal measure or unity.	Length.	Capacity.	Weight.	Agrarian.	For firewood.
10,000 1,000 100 10 0 0.1 0.01 0.001	Myria Kilo Hecto Deca —— Deci Centi Milli	Metre.	Litre.	Gramme.	Are.	Stere.
Proportion of the principal measures between themselves and the length of the meridian.		10,000,000th part of the distance from the pole to the equator.	A decimetre cube.	Weight of a centimetre cube of distilled water.	100 square metres.	One cubic metre.
Value of the principal measures in the ancient French measures.		3 feet 11 lines and $\frac{1}{2}$ nearly	1 pint and $\frac{1}{20}$ or 1 litron and $\frac{1}{4}$ nearly.	18 grains and 841,000 parts.	Two square perches dex eaux et forêt.	1 demi-voie, or $\frac{1}{4}$ of a cord des eaux et forêt.
Value in English measures.		Inches 39.383.	61.083 inches, which is more than the wine, and less than the beer quart.	22,966 grains.	11.968 square yards.	

The English avoirdupois pound weighs troy grains 7004; whence the avoirdupois ounce, whereof 16 make a pound, is found equal to 437.75 troy grains.—And it follows that the troy pound is to the avoirdupois pound as 88 to 107 nearly; for as 88 to 107, so is 5760 to 7003.636. that the troy ounce is to the avoirdupois ounce, as 80 to 73 nearly; for as 80 to 73, so is 480 to 438. And, lastly, That the avoirdupois pound and ounce is to the Paris two marc weight and ounce, as 63 to 68 nearly; for as 63 to 68, so is 7004 to 7559.873. See WEIGHT. The Paris foot, expressed in decimals, is equal to 1.0654 of the English foot, or contains 12.785 English inches. See FOOT.

3.] The standard in *Holland*, *Flanders*, *Sweden*, a good part of *Germany*, many of what were formerly called the *Hans-towns*, as *Dantzick* and *Hamburgh*, and at *Geneva*, *Frankfort*, &c. is likewise the ell: but the ell in all these places differs from the Paris ell. In Holland it contains one Paris foot eleven lines, or four-sevenths of the Paris ell. The Flanders ell contains two feet one inch five lines and half a line; or seven-twelfths of the Paris ell. The ell of Germany, Brabant, &c. is equal to that of Flanders.

4.] The *Italian* measure is the branchio, brace, or fathom. This obtains in the states of Modena, Venice, Florence, Lucca, Milan, Mantua, Bologna, &c. but is of different lengths. At Venice, it contains one Paris foot eleven inches three lines, or eight-fifteenths of the Paris ell. At Bologna, Modena, and Mantua, the brace is the same as at Venice. At Lucca it contains one Paris foot nine inches ten lines, or half a Paris ell. At Florence, it contains one foot nine inches four lines, or forty-nine hundredths of a Paris ell. At Milan, the brace for measuring of silks is one Paris foot seven inches four lines, or four-ninths of a Paris ell: that for woollen cloths is the same with the ell of Holland. Lastly, at Bergama, the brace is one foot seven inches six lines, or five-ninths of a Paris ell. The usual measure at Naples, however, is the canna, containing six feet ten inches and two lines, or one Paris ell and fifteen-seventeenths.

5.] The *Spanish* measure is the vara or yard, in some places called the bara; containing seventeen twenty-fourths of the Paris ell. But the measure in Castile and Valencia is the pan, span, or palm; which is used, together with the canna, at Genoa. In Arragon, the vara is equal to a Paris ell and a half, or five feet five inches six lines.

6.] The *Portuguese* measure is the cavedos, containing two feet eleven lines, or four-sevenths of a Paris ell; and the vara, an hundred and six whereof make an hundred Paris ells.

7.] The *Piedmontese* measure is the ras, containing one

one Paris foot nine inches ten lines, or half a Paris ell. In Sicily, their measure is the canna, the same with that of Naples.

8.] The *Muscovy* measures are the cubit, equal to one Paris foot four inches two lines; and the arcin, two whereof are equal to three cubits.

9.] The *Turkish* and *Levant* measures are the picq, containing two feet two inches and two lines, or three-fifths of the Paris ell. The Chinese measure, the cobre; ten whereof are equal to three Paris ells. In Persia, and some parts of the Indies, the gueze, whereof there are two kinds; the royal gueze, called also the *gueze monkelser*, containing two Paris feet ten inches eleven lines, or four-fifths of the Paris ell; and the shorter gueze, called simply *gueze*, only two-thirds of the former. At Goa and Ormuz, the measure is the vara, the same with that of the Portuguese, having been introduced by them. In Pegu, and some other parts of the Indies, the cando or candi, equal to the ell of Venice. At Goa, and other parts, they use a larger cando, equal to seventeen Dutch ells; exceeding that of Babel and Balsora by $\frac{7}{8}$ per cent. and the vara by $6\frac{1}{2}$. In Siam, they use the ken, short of three Paris feet by one inch. The ken contains two soks, the sok two keubs, the keub twelve nious or inches, the niou to be equal to eight grains of rice, i. e. to about nine lines. At Camboia, they use the haster; in Japan, the tatam; and the span on some of the coasts of Guinea.

Tables of Long Measure.

1. English.

Barley-corn											
3	Inch										
9	3	Palm									
27	9	3	Span								
36	12	4	$1\frac{1}{3}$	Foot							
54	18	6	2	$1\frac{1}{2}$	Cubit						
108	36	12	4	3	2	Yard					
180	60	20	$6\frac{2}{3}$	5	$3\frac{1}{3}$	$1\frac{2}{3}$	Pace				
216	72	24	8	6	4	2	$1\frac{1}{5}$	Fathom			
594	198	66	22	$16\frac{1}{2}$	11	$5\frac{1}{2}$	$3\frac{3}{10}$	$2\frac{3}{4}$	Pole		
23760	7920	2640	880	660	440	220	132	110	40	Furlong	
190080	63360	21120	7040	5280	3520	1760	1056	880	320	8	Mile.

2. Scripture *Measures reduced into English.*

								Eng. feet.	Inch. Dec.
Digit								0	0.912
4	Palm							0	3.648
12	3	Span						0	10.944
24	6	2	Cubit					1	9.888
96	24	8	4	Fathom				7	3.552
144	36	12	6	$1\frac{1}{2}$	Ezekiel's reed			10	11.328
192	48	16	8	2	$1\frac{1}{3}$	Arabian pole		14	7.104
1920	480	160	80	20	$13\frac{1}{3}$	10	Schœnus, or measuring line	145	11.04

3. The

3. *The* Scripture *Itinerary Measures.*

						Eng. Miles.	Paces.	Feet.
Cubit						0	0	1.824
400	Stadium					0	145	4.6
2000	5	Sabbath day's journey				0	729	3.000
4000	10	2	Eastern mile			1	403	1.000
12000	30	6	3	Parasan		4	153	3.000
96000	240	48	24	8	A day's journey	33	172	4.000

4. Grecian.

												Paces.	Feet.	Dec.
Dactylus, digit												0	0	0.7554 $\frac{11}{16}$
4	Doron, dochme											0	0	3.0218 $\frac{3}{4}$
10	$2\frac{1}{2}$	Lichas										0	0	7.5546 $\frac{7}{8}$
11	$2\frac{3}{4}$	$1\frac{1}{10}$	Orthodoron									0	0	8.3101 $\frac{9}{10}$
12	3	$1\frac{1}{5}$	$1\frac{1}{11}$	Spithame								0	0	9.0656 $\frac{1}{4}$
16	4	$1\frac{6}{10}$	$1\frac{5}{11}$	$1\frac{1}{3}$	Foot							0	1	0.0875
18	$4\frac{1}{2}$	$1\frac{4}{5}$	$1\frac{7}{11}$	$1\frac{1}{2}$	$1\frac{1}{8}$	Cubit						0	1	1.5984 $\frac{3}{8}$
20	5	2	$1\frac{9}{11}$	$1\frac{2}{3}$	$1\frac{1}{4}$	$1\frac{1}{9}$	Pygon					0	1	3.109 $\frac{3}{8}$
24	6	$2\frac{2}{5}$	$2\frac{2}{11}$	2	$1\frac{1}{2}$	$1\frac{1}{3}$	$1\frac{1}{5}$	Cubic larger				0	1	6.13125
96	24	$9\frac{3}{5}$	$8\frac{8}{11}$	8	6	$5\frac{1}{3}$	$4\frac{4}{5}$	4	Pace			0	6	0525
9600	2400	960	$872\frac{8}{11}$	800	600	$533\frac{1}{3}$	480	400	100	Furlong		100	4	4.5
76800	19200	7680	$6981\frac{9}{11}$	6400	6800	$4266\frac{2}{3}$	3840	3200	800	8	Mile	805	5	0

5. Roman.

										Paces.	Feet.	Dec.
Digitus transversus										0	0	0.725 $\frac{1}{4}$
$1\frac{1}{3}$	Uncia									0	0	0.967
4	3	Palmus minor								0	0	2.901
16	12	4	Pes							0	0	11.604
20	15	5	$1\frac{1}{2}$	Palmipes						0	1	2.505
24	18	6	$1\frac{1}{2}$	$1\frac{1}{5}$	Cubitus					0	1	5.406
40	40	10	$2\frac{1}{2}$	2	$1\frac{2}{3}$	Gradus				0	2	5.01
80	60	20	5	4	$3\frac{1}{3}$	2	Passus			0	4	10.02
10000	7500	2500	625	500	$416\frac{2}{3}$	250	125	Stadium		120	4	4.5
80000	60000	20000	5000	4000	$3333\frac{1}{3}$	2000	1000	8	Milliare	967	0	0.

Measure.

6. *Proportion of several Long Measures to each other, by M. Picard.*

The Rhinland or Leyden foot (12 whereof make the Rhinland perch) supposed	696
The English foot - - -	675½
The Paris foot -	720
The Amsterdam foot, from that of Leyden, by Snellius - - -	629
The Danish foot (two whereof make the Danish ell) - -	$701\frac{8}{10}$
The Swedish foot - -	658¼
The Brussels foot - -	$609\frac{1}{5}$
The Dantzick foot, from Hevelius's Selenographia - - .	636
The Lyons foot, by M. Auzout -	$757\frac{2}{5}$
The Bologna foot, by the same -	843
The braccio of Florence, by the same, and Father Marsenne - -	1290
The palm of the architects at Rome, according to the observations of Messrs Picard and Auzout - - -	419¼
The Roman foot in the Capitol, examined by Messrs Picard and Auzout -	653 or 653½
The same from the Greek foot -	652
From the vineyard Mattei - -	657½
From the palm -	658¼
From the pavement of the Pantheon, supposed to contain 10 Roman feet -	653
From a slip of marble in the same pavement, supposed to contain three Roman feet	650
From the pyramid of Cestius, supposed to contain 95 Roman feet -	653½
From the diameters of the columns in the arch of Septimius Severus	$653\frac{1}{3}$
From a slip of porphyry in the pavement of the Pantheon -	$653\frac{1}{3}$

See on this subject Phil. Trans. vol. iv. art. 69. p. 774.

7. *Proportions of the Long Measures of several nations to the English foot, taken from Messrs Greaves, Auzout, Picard, and Eisenchmid.* See Foot.

The English standard foot being divided into 1000 equal parts, the other measures will have the proportions to it, which follow.

	Feet.	Inches.
English foot -	1000	12
Paris foot -	1068	12.816
Venetian foot - -	1161	13.944
Rhinland foot -	1033	12.396
Strasburgh foot -	952	14.424
Norimberg foot -	1000	12
Dantzick foot -	944	11.328
Danish foot - -	1042	12.504
Swedish foot -	977¾	11.733
Derahor cubit of Cairo -	1824	12.888
Persian arish - -	3197	38.364
Greater Turkish pike -	2200	26.4
Lesser Turkish pike -	2131	25.572
Braccio at Florence -	1913	22.956
Braccio for woollen at Si enn	1242	14.904
Braccio for linen at Sienna	1974	23.688
Canna at Naples - -	6880	82.56
Vera at Almaria and Gibraltar	2760	33.12
Palmo di Arehtetti at Rome -	732	87.84
Canna di Archtetti -	7320	87.84
Palmo di braccio di mercantia	695½	83.46
Genoa palm -	815	9.78
Bolognian foot -	1250	15
Antwerp ell -	2283	27.396
Amsterdam ell - -	2268	27.216
Leyden ell -	2260	27.12
Paris draper's ell -	3929	47.148
Paris mercer's ell -	3939	47.244

8. *Different Itinerary Measures.*

A French league is about	2¾	English miles
A German mile	4	ditto
A Dutch mile	3½	ditto
An Italian mile	$\frac{1}{1}\frac{1}{2}$	ditto
A Spanish league	$3\frac{2}{5}$	ditto
A Russian verst	¾	ditto

II. Square, Superficial, or *Land Measure.*

1. *English* square measures are raised from the yard of 36 inches multiplied into itself, and thus producing 1296 square inches in the square yard; the divisions of this are square feet and inches; and the multiples, poles, roods, and acres. Because the length of a pole is 5½ yards, the square of the same contains 30¼ square yards. A square mile contains 640 square acres. In measuring fens and woodlands, 18 feet are generally allowed to the pole, and 21 feet in forest lands.

A hide of land, frequently mentioned in the earlier part of the English history, contained about 100 arable acres; and 5 hides were esteemed a knight's fee. At the time of the Norman conquest, there were 243,600 hides in England.

2. *Scotch* square or land measure is regulated by the Scotch ell: 36 square ells = 1 fall, 40 falls = 1 rood, 4 roods = 1 acre.—The proportion between the Scotch and English acre, supposing the feet in both measures alike, is as 1369 to 1089, or nearly as 5 to 4. If the difference of the feet be regarded, the proportion is as 10,000 to 7869. The length of the chain for measuring land in Scotland is 23 ells, or 74 feet.—A husband-land contains 6 acres of sock and scythe land, that is, of land that may be tilled with a plough or mown with a scythe; 13 acres of arable land make one ox-gang, and four ox-gangs make a pound-land of old extent.

3. *French* square measures are regulated by 12 square lines in the inch square; 12 inches in the foot, 22 feet in the perch, and 100 perches in the arpent or acre.

Tables of Square Measure.

1. English.

Inches						
144	Feet					
1296	9	Yards				
3600	25	$2\frac{7}{9}$	Paces			
39204	$272\frac{1}{4}$	$30\frac{1}{4}$	10.89	Poles		
1568160	10890	1210	435.6	40	Rood	
6272640	43560	4840	1743.6	160	4	Acre

2. *Grecian* square measures were the plethron or acre, by some said to contain 1444, by others 10,000 square feet; and aroura, the half of the plethron. The aroura of the Egyptians was the square 100 cubits.

3. *Roman* square measure reduced to English. The integer was the jugerum or acre, which the Romans divided like the libra or as: thus the jugerum contained

	Square feet.	Scruples.	English roots.	Sq. poles.	Square feet.
As	28800	288	2	18	250.05
Deunx	26400	264	2	10	183.85
Dextans	24000	240	2	2	117.64
Dodrans	21600	216	1	34	51.42
Bes	19200	192	1	25	257.46
Septunx	16800	168	1	17	191.25
Semis	14400	144	1	9	125.03
Quincunx	12000	120	1	1	58.82
Triens	9600	96	0	32	264.85
Quadrans	7200	72	0	24	198.64
Sextans	4800	48	0	16	132.43
Uncia	2400	24	0	8	66.21

Note, Actus major was 14,400 square feet, equal to a semis; clima, 3600 square feet, equal to sescuncia; and actus minimus equal to a sextans.

III. *Cubical Measures*, or Measures of Capacity, for Liquids.

1. The *English* measures were originally raised from troy weight: it being enacted by several statutes, that eight pounds troy of wheat, gathered from the middle of the ear, and well dried, should weigh a gallon of wine measure, the divisions and multiples whereof were to form the other measures; at the same time it was also ordered, that there should be but one liquid measure in the kingdom: yet custom has prevailed; and there having been introduced a new weight, viz. the avoirdupois, we have now a second standard gallon adjusted thereto, and therefore exceeding the former in the proportion of the avoirdupois weight to troy weight. From this latter standard are raised two several measures, the one for ale, the other for beer. The sealed gallon at Guildhall, which is the standard for wines, spirits, oils, &c. is supposed to contain 231 cubic inches; and on this supposition the other measures raised therefrom will contain as in the table underneath: yet, by actual experiment, made in 1688, before the lord mayor and the commissioners of excise, this gallon was found to contain only 224 cubic inches: it was, however, agreed to continue the common supposed contents of 231 cubic inches: so that all computations stand on their own footing. Hence, as 12 is to 231, so is $14\frac{12}{20}$ to $281\frac{1}{4}$ the cubic inches in the ale gallon: but in effect the ale quart contains $70\frac{1}{2}$ cubic inches, on which principle the ale and beer gallon will be 282 cubic inches. The several divisions and multiples of these measures, and their proportions, are exhibited in the tables underneath.

The barrel for ale in London is 32 gallons, and the barrel for beer 36 gallons. In all other places of England, the barrel, both for ale and beer, is 34 gallons.

2. *Scotch* liquid measure is founded on the pint. The Scotch pint was formerly regulated by a standard jug of cast metal, the custody of which was committed to the borough of Stirling. This jug was supposed to contain 105 cubic inches; and though, after several careful trials, it has been found to contain only about $103\frac{1}{2}$ inches; yet, in compliance with established custom, founded on that opinion, the pint *stoups* are still regulated to contain 105 inches, and the customary ale measures are about $\frac{1}{16}$ above that standard. It was enacted by James I. of Scotland, that the pint should contain 41 ounces trone weight of the clear water of Tay, and by James VI. that it should contain 55 Scots troy ounces of the clear water of Leith. This affords another method of regulating the pint, and also ascertains the ancient standard of the trone weight. As the water of Tay and Leith is alike, the trone weight must have been to the Scots troy weight as 55 to 41; and therefore the pound trone must have contained about $21\frac{1}{2}$ ounces Scots troy.

4 gills	=	1 mutchkin.
2 mutchkins	=	1 chopin.
2 chopins	=	1 pint.
2 pints	=	1 quart.
4 quarts	=	1 gallon.

The Scotch quart contains 210 inches; and is, therefore, about $\frac{1}{10}$ less than the English wine gallon, and about $\frac{1}{4}$ less than the ale gallon.

3. As to the liquid measures of foreign nations, it is to be observed, that their several vessels for wine, vinegar, &c. have also various denominations according to their different sizes and the places wherein they are used. The woeders of Germany, for holding Rhenish and Moselle wines, are different in their gauges; some containing 14 aumes of Amsterdam measure, and others more or less. The aume is reckoned at Amsterdam for 8 steckans, or 20 verges, or for $\frac{1}{6}$ of a tun of 2 pipes, or 4 barrels, of French or Bourdeaux, which $\frac{1}{6}$ at this latter place is called *tierçon*, because

Measure. because 3 of them make a pipe or 2 barrels, and 6 the said tun. The steckan is 16 mingles, or 32 pints; and the verge is, in respect of the said Rhenish and Moselle, and some other sorts of wine, 6 mingles; but, in measuring brandy it consists of $6\frac{1}{6}$ mingles. The aume is divided into 4 anckers, and the ancker into 2 steckans, or 32 mingles. The ancker is taken sometimes for $\frac{1}{24}$ of a tun, or 4 barrels; on which footing the Bourdeaux barrel ought to contain at Amsterdam (when the cask is made according to the just gauge) $12\frac{1}{2}$ steckans, or 200 mingles, wine and lees; or 12 steckans, or 192 mingles, racked wine; so that the Bourdeaux tun of wine contains 50 steckans, or 800 mingles, wine and lees; and 48 steckans, or 768 mingles, of pure wine. The barrels or poinçons of Nantes and other places on the river Loire, contain only 12 steckans, Amsterdam measure. The wine tun of Rochelle, Cogniac, Charente, and the isle of Rhé, differs very little from the tun of Bourdeaux, and consequently from the barrels and pipes. A tun of wine of Chalosse, Bayonne, and the neighbouring places, is reckoned 60 steckans, and the barrel 15, Amsterdam measure.

The muid of Paris contains 150 quarts or 300 pints, wine and lees; or 280 pints clear wine; of which muids 3 make a tun, and the fractions are,

The muid	containing	36 setiers
The setier		4 quarts
The quart		2 pints
The pint		2 chopins
The chopin		2 demi-setiers
The demi-setier		2 poissons

The muid is also composed of pipes or poinçons, quarteaux, queves, and demiqueves; those poinçons of Paris and Orleans contain about 15 steckans Amsterdam measure, and ought to weigh with the cask 666lb. a little more or less. In Provence they reckon by milleroles, and the millerole of Toulon contains 66 Paris pints, or 100 pints of Amsterdam, nearly, and the Paris pint is nearly equal to the English wine quart (A).

The butts or pipes from Cadiz, Malaga, Alicant, Benecarlo, Saloe, and Mataro, and from the Canaries, from Lisbon, Oporto, and Fayal, are very different in their gauges, though in affreightments they are all reckoned two to the tun.

Vinegar is measured in the same manner as wine; but the measures for brandies are different: these spirits from France, Spain, Portugal, &c. are generally shipped in large casks called *pipes*, *butts* and *pieces*, according to the places from whence they are imported, &c. In France, brandy is shipped in casks called *pieces* at Bourdeaux, and *pipes* at Rochelle, Cogniac, the isle of Rhé, and other neighbouring places, which contain some more and some less, even from 60 to 90 Amsterdam verges or veertels, according to the capacity of the vessels, and the places they come from, which, being reduced into barrels, will stand as follows, viz.

At Rochelle, Cogniac, the isle of Rhé, and the country of Aunis,	27 Veertels	per barrel.
At Nantes, and several places of Bretagne and Anjou	29 Veertels	
At Bourdeaux, and different parts of Guienne	32 Verges	
At Amsterdam, and other cities of Holland	30 Veertels	
At Hamburgh and Lubeck	30 Verges	
At Embden	27 Verges	

In Provence and Languedoc, brandy is sold by the quintal, the casks included; and at Bruges in Flanders, the verges are called *sesters* of 16 stops each, and the spirits is sold at so much per stop.

Olive oil is also shipped in casks of various sizes, according to the custom of the places where it is embarked, and the conveniency of stowage. In England it is sold by the tun of 236 gallons; and at Amsterdam by the tun of 717 mingles, or 1434 pints. In Provence it is sold by milleroles of 66 Paris pints; from Spain and Portugal it is brought in pipes or butts, of different gauges; at the first place it is sold by roves, where 40 go to the butt; and at the latter place by almoudas, whereof 26 make a pipe. Train oil is sold in England by the tun, at Amsterdam by the barrel.

Tables of Liquid Measure.

1. English.

[*Wine.*]

Solid inches										
$28\frac{7}{8}$	Pint									
231	8	Gallon								
4158	144	18	Rundlet							
$7276\frac{1}{2}$	252	$31\frac{1}{2}$	$1\frac{3}{4}$	Barrel						
9702	336	42	$2\frac{1}{3}$	$1\frac{2}{3}$	Tierce					
14553	504	63	$3\frac{1}{2}$	2	$1\frac{1}{2}$	Hogshead				
19279	672	84	$4\frac{2}{3}$	$2\frac{2}{3}$	2	$1\frac{1}{3}$	Puncheon			
29106	1008	126	7	4	3	2	$1\frac{1}{2}$	Butt or pipe		
58212	2016	252	14	8	6	4	3	2	Tun.	

[*Ale*]

Pints					
8	Gallon				
64	8	Firkin			
128	16	2	Kilderkin		
256	32	4	2	Barrel	
512	64	8	4	2	Hogsh.

[*Beer.*]

Pints					
8	Gallon				
72	9	Firkin			
144	18	2	Kilderkin		
288	36	4	2	Barrel	
576	72	8	4	2	Hogsh.

2. Jewish

(A) These are the old measures of France, the account of which, for the sake of comparison, is here retained.

Measure.

2. Jewish reduced to English Wine Measure.

							Gall.	Pints	Solid inches.
Caph							0	$0\frac{5}{8}$	0.177
$1\frac{1}{3}$	Log						0	$0\frac{5}{6}$	0.211
$5\frac{1}{3}$	4	Cab					0	$3\frac{1}{3}$	0.844
16	12	3	Hin				1	2	2.533
32	24	6	2	Seah			2	4	5.067
96	72	18	6	3	Bath, or Epha		7	4	15.2
960	720	180	60	30	10	Coron, or Chomer	75	5	7.625

3. Attic reduced to English Wine Measure.

										Gal.	Pints.	Sol. Inch. Dec.
Cochliarion										0	$\frac{1}{120}$	$0.0356\frac{5}{12}$
2	Cheme									0	$\frac{1}{60}$	$0.0712\frac{5}{6}$
$2\frac{1}{2}$	$1\frac{1}{4}$	Mystrone								0	$\frac{1}{48}$	$0.089\frac{11}{48}$
5	$2\frac{1}{2}$	2	Conche							0	$\frac{1}{24}$	$0.178\frac{11}{24}$
10	5	4	2	Cyathos						0	$\frac{1}{12}$	$0.356\frac{11}{12}$
15	$7\frac{1}{2}$	6	3	$1\frac{1}{2}$	Oxybaphon					0	$\frac{1}{8}$	$0.535\frac{3}{8}$
60	30	24	12	6	4	Cotyle				0	$\frac{1}{2}$	$2.141\frac{1}{2}$
120	60	48	24	12	8	2	Xestes			0	1	4.283
720	360	288	144	72	48	12	6	Chous		0	6	25.698
8640	4320	3456	1728	864	576	144	72	12	Metretes	10	2	19.629

4. Roman reduced to English Wine Measure.

										Gal.	Pints.	Sol. inch. Dec.
Ligula										0	$0\frac{1}{48}$	$0.117\frac{5}{12}$
4	Cyathus									0	$0\frac{1}{12}$	$0.469\frac{2}{3}$
6	$1\frac{1}{2}$	Acetabulum								0	$0\frac{1}{8}$	$0.704\frac{1}{2}$
12	3	2	Quartarius							0	$0\frac{1}{4}$	1.40
24	6	4	2	Hemina						0	$0\frac{1}{2}$	2.818
48	12	8	4	2	Sextarius					0	1	5.636
288	72	48	24	12	6	Congius				0	7	4.942
1152	288	192	96	48	24	4	Urna			3	$4\frac{1}{2}$	5.33
2304	576	384	192	96	48	8	2	Amphora		7	1	10.66
46080	11520	7680	3840	1920	96	160	40	20	Culeus	143	3	11.095

IV. *Measures*

Measure.

IV. *Measure of Capacity for things Dry.*

1.] *English* dry or corn measure. The standard for measuring corn, salt, coals, and other dry goods, in England, is the Winchester gallon, which contains $272\frac{1}{4}$ cubic inches. The bushel contains 8 gallons, or 2178 inches. A cylindrical vessel, $18\frac{1}{2}$ inches diameter, and 8 inches deep, is appointed to be used as a bushel in levying the malt tax. A vessel of these dimensions is rather less than the Winchester bushel of 8 gallons, for it contains only 2150 inches; though probably there was no difference intended. The denominations of dry measure commonly used, are given in the first of the subjoined tables. Four quarters corn make a chaldron, 5 quarters make a wey or load, and 10 quarters make a ton. In measuring sea coal, 5 pecks make a bushel, 9 bushels make a quarter or vatt, 4 quarters make a chaldron, and 21 chaldrons make a score.

40 feet hewn timber make a load.
50 feet unhewn timber make a load.
32 gallons make a herring barrel.
42 gallons make a salmon barrel.
1 cwt. gunpowder makes a barrel.
256 lbs. soap make a barrel.
10 dozen candles make a barrel.
12 barrels make a last.

2.] *Scotch* dry measure. There was formerly only one measure of capacity in Scotland; and some commodities were heaped, others *straiked*, or measured exactly to the capacity of the standard. The method of heaping was afterwards forbidden as unequal, and a larger measure appointed for such commodities as that custom had been extended to.

The wheat firlot, used also for rye, pease, beans, salt, and grass seeds, contains 21 pints 1 mutchkin, measured by the Stirling jug. The barley firlot, used also for oats, fruit, and potatoes, contains 31 pints. A different method of regulating the firlot was appointed from the dimensions of a cylindrical vessel. The diameter for both measures was fixed at $19\frac{1}{6}$ inches, the depth $7\frac{1}{7}$ inches for the wheat firlot, and $10\frac{1}{2}$ for the barley firlot. A standard construeted by these measures is rather less than when regulated by the pint; and as it is difficult to make vessels exactly cylindrical, the regulation by the pint has prevailed, and the other method gone into disuse.

If the Stirling jug contains $103\frac{1}{5}$ inches, the wheat firlot will contain 2109 inches; which is more than 2 per cent. larger than the legal malt bushel of England, and about 1 per cent. larger than the Winchester bushel: and the barley firlot will contain 3208 inches. The barley boll is nearly equal to six legal malt bushels.

In Stirlingshire, 17 pecks are reckoned to the boll: in Inverness-shire, 18 pecks: in Ayrshire the boll is the same as the English quarter. And the firlots, in many places, are larger than the Linlithgow standard.

3.] *French dry*, are, the litron, bushel, minot, mine, septier, muid, and tun. The litron is divided into two demilitrons, and four quarter litrons, and contains 36 cubic inches of Paris. By ordonnance, the litron is to be three inches and a half high, and three inches 10 lines broad. The litron for salt is larger, and is divided into two halves, four quarters, eight demi-quarters, and 16 mesurettes. The French bushel is different in different jurisdictions. At Paris it is divided into demibushels; each demibushel into two quarts; the quart into two half quarts; and the half quart into two litrons: so that the bushel contains 16 litrons. By ordonnance the Paris bushel is to be eight inches two lines and a half high, and ten inches broad, or in diameter within-side. The minot consists of three bushels, the mine of two minots or six bushels, the septier of two mines or 12 bushels, and the muid of 12 septiers or 144 bushels. The bushel of oats is estimated double that of any other grain: so that there go 24 bushels to make the septier, and 288 to make the muid. It is divided into four picotins, the picotin containing two quarts, or four litrons. The bushel for salt is divided into two half bushels, four quarters, eight half quarters, and 16 litrons: four bushels make a minot, 16 a septier, and 192 a muid. The bushel for wood is divided into halves, quarters, and half quarters. Eight bushels make the minot, 16 a mine; 20 mines or 320 bushels, the muid. For plaster, 12 bushels make a sack, and 36 sacks a muid. For lime, three bushels make a minot, and 48 minots a muid. The minot is by ordonnance to be 11 inches 9 lines high, and 14 inches 8 lines in diameter. The minot is composed of three bushels, or 16 litrons: four minots make a septier, and 48 a muid. The French mine is no real vessel, but an estimation of several others. At Paris the mine contains six bushels, and 24 make the muid; at Rouen the mine is four bushels; and at Dieppe 18 mines make a Paris muid. The septier differs in different places: at Paris it contains two mines, or eight bushels, and 12 septiers the muid. At Rouen the septier contains two mines or 12 bushels. Twelve septiers make a muid at Rouen as well as at Paris; but 12 of the latter are equal to 14 of the former. At Toulon the septier contains a mine and a half; three of which mines make the septier of Paris. The muid or muy of Paris consists of 12 septiers; and is divided into mines, minots, bushels, &c. That for oats is double that for other grain, i. e. contains twice the number of bushels. At Orleans the muid is divided into mines, but those mines only contain two Paris septiers and a half. In some places they use the tun in lieu of the muid; particularly at Nantes, where it contains 10 septiers of 16 bushels each, and weighs between 2200 and 2250 pounds. Three of these tuns make 28 Paris septiers. At Rochelle, &c. the tun contains 42 bushels, and weighs two per cent. less than that of Nantes. At Brest it contains 20 bushels, is equal to 10 Paris septiers, and weighs about 2240 pounds. See TUN.

4.] *Dutch, Swedish, Polish, Prussian*, and *Muscovite*. In these places, they estimate their dry things on the foot of the *last, lest, leth*, or *lecht*; so called according to the various pronunciations of the people who use it. In Holland, the last is equal to 19 Paris septiers, or 38 Bourdeaux bushels, and weighs about 4560 pounds; the last they divide into 27 mudes, and the mude into four scheples. In Poland, the last is 40 Bourdeaux bushels, and weighs about 4800 Paris pounds. In Prussia, the last is 133 Paris septiers. In Sweden and Muscovy they measure by the great and little last; the first containing 12 barrels, and the second half as many. See LAST.

LAST. In Muscovy, they likewise use the chefford, which is different in various places: that of Archangel is equal to three Rouen bushels.

5.] *Italian.* At Venice, Leghorn, and Lucca, they estimate their dry things on the foot of the staro or staio; the staro of Leghorn weighs 54 pounds: 112 staros and seven-eighths are equal to the Amsterdam last. At Lucca, 119 staros make the last of Amsterdam. The Venetian staro weighs 128 Paris pounds: the staro is divided into four quarters. Thirty-five staros and one-fifth, or 140 quarters and four-fifths, make the last of Amsterdam. At Naples and other parts, they use the tomolo or tomalo, equal to one-third of the Paris septier. Thirty-six tomoli and a half make the carro, and a carro and a half, or 54 tomoli, make the last of Amsterdam. At Palermo, 16 tomoli make the salma, and four mondili the tomolo. Ten salmas and three-sevenths, or 171 tomoli and three-sevenths, make the last of Amsterdam.

6.] *Flemish.* At Antwerp, &c. they measure by the viertel; 32 and one-half whereof make 19 Paris septiers. At Hamburgh, the schepel; 90 whereof make 19 Paris septiers.

7.] *Spanish* and *Portuguese.* At Cadiz, Bilboa, and St Sebastian, they use the fanega; 23 whereof make the Nantes or Rochelle tun, or 9 Paris septiers and a half: though the Bilboa fanega is somewhat larger, insomuch that 21 fanegas make a Nantes tun. At Seville, &c. they use the anagoras, containing a little more than the Paris mine; 36 anagoras make 19 Paris septiers. At Bayonne, &c. the concha; 30 whereof are equal to nine Paris septiers and a half. At Lisbon, the alquiver, a very small measure, 240 whereof make 19 Paris septiers, 60 the Lisbon muid.

TABLES of DRY Measure.

1. ENGLISH.

Solid inches					
33.6	Pint				
268.8	8	Gallon			
537.6	16	2	Peck		
2150.4	64	8	4	Bush	
17203.2	512	64	32	8	Quarter.

2. SCRIPTURE Dry, reduced to English.

							Peck.	Gall.	Pint.	Dec. Sol. inch.
Gachal							0	0	$0\frac{17}{120}$	0.031
20	Cab						0	0	$2\frac{5}{6}$	0.073
36	$1\frac{4}{5}$	Gomor					0	0	$5\frac{1}{10}$	1.211
120	6	$3\frac{1}{3}$	Seah				1	0	1	4.036
360	18	10	3	Epha			3	0	3	12.107
1800	90	50	15	5	Leteeh		16	0	0	26.500
3600	180	100	30	10	2	Chomer, or coron	32	0	1	18.969

Measure. Measure.

3. ATTIC Measures of Capacity for Things dry, reduced to English Corn Measure.

							Peck.	Gal.	Pint.	Dec. Sol. inch
						Cochliarion	0	0	0	0.276 $\frac{7}{20}$
10						Cyathos	0	0	0	2.763 $\frac{1}{2}$
15	1½					Oxybaphon	0	0	0	4.144 $\frac{3}{4}$
60	6	4				Cotyle	0	0	0	16.579
120	12	8	2			Xestes	0	0	0	33.158
180	18	12	3	1½		Choenix	0	0	1	15.705 $\frac{1}{4}$
8640	864	576	144	72	48	Medimnos	4	0	6	3.501

4. ROMAN Measures of Capacity for Things dry, reduced to English Corn Measure.

							Peck.	Gall.	Pint.	Dec. Sol. inch
						Ligula	0	0	0 $\frac{1}{48}$	0.01
4						Cyathus	0	0	0 $\frac{1}{12}$	0.04
6	1½					Acetabulum	0	0	0 $\frac{1}{8}$	0.06
24	6	4				Hemina	0	0	8 $\frac{1}{2}$	0.24
48	12	8	2			Sextarius	0	0	1	0.48
384	96	64	16	8		Semimodius	0	1	0	3.84
768	192	128	32	16	2	Modius	1	0	0	7.68

MEASURE of Wood for Firing, is usually the cord four feet high, and as many broad, and eight long; this is divided into two half cords, called *ways*, and by the French *membrures*, from the pieces stuck upright to bound them; or *voyes*, as being supposed half a waggon load.

MEASURE for Horses, is the hand, which by statute contains four inches.

MEASURE, among *Botanists.* In describing the parts of plants, Tournefort introduced a geometrical scale, which many of his followers have retained. They measured every part of the plant; and the essence of the description consisted in an accurate mensuration of the whole.

As the parts of plants, however, are liable to variation in no circumstance so much as that of dimension, Linnæus very rarely admits any other mensuration than that arising from the respective length and breadth of the parts compared together. In cases that require actual mensuration, the same author recommends, in lieu of Tournefort's artificial scale, the following natural scale of the human body, which he thinks is much more convenient, and equally accurate.

The scale in question consists of 11 degrees, which are as follow: 1. A hair'sbreadth, or the diameter of a hair, (*capillus*). 2. A line, (*linea*), the breadth of the crescent or white appearance at the root of the finger (not. thumb, measured from the skin towards the body of the nail; a line is equal to 12 hairbreadths, and is the 12th part of a Parisian inch. 3. A nail (*unguis*), the length of a finger nail; equal to six lines, or half a Parisian inch. 4. A thumb (*pollex*), the length of the first or outermost joint of the thumb; equal to a Parisian inch. 5. A palm (*palmus*), the breadth of the palm exclusive of the thumb; equal to three Parisian inches. 6. A span (*spithama*), the distance between the extremity of the thumb and that of the first finger when extended; equal to seven Parisian inches. 7. A great span (*dodrans*), the distance between the extremity of the thumb and that of the little finger, when extended; equal to nine inches. 8. A foot (*pes*), measuring from the elbow to the basis of the thumb; equal to 12 Parisian inches. 9. A cubit (*cubitus*), from the elbow to the extremity of the middle finger; equal to 17 inches. 10. An arm length (*brachium*), from the armpit to the extremity of the middle finger; equal to 24 Parisian inches, or two feet. 11. A fathom (*orgya*), the measure of the human stature; the distance between the extremities of the two middle fingers, when the arms are extended; equal, where greatest, to six feet.

MEASURE is also used to signify the cadence and time observed in poetry, dancing, and music, to render them regular and agreeable.

The different measures or metres in poetry, are the different

Measure. different manners of ordering and combining the quantities, or the long and short syllables. Thus, hexameter, pentameter, iambic, sapphic verses, &c. consist of different measures.

In English verses, the measures are extremely various and arbitrary, every poet being at liberty to introduce any new form that he pleases. The most usual are the heroic, generally consisting of five long and five short syllables; and verses of four feet; and of three feet and a cæsura, or single syllable.

The ancients, by variously combining and transposing their quantities, made a vast variety of different measures. Of words, or rather feet of two syllables, they formed a spondee, consisting of two long syllables; a pyrrhic, of two short syllables; a trochee, of a long and a short syllable; and an iambic, of a short and a long syllable.

Of their feet of three syllables they formed a molossus, consisting of three long syllables; a tribrach, of three short syllables; a dactyl, of one long and two short syllables; and an anapæst, of two short and one long syllable. The Greek poets contrived 124 different combinations or measures, under as many different names, from feet of two syllables to those of six.

Measure, in *Music*, the interval or space of time which the person who beats time takes between the rising and falling of his hand or foot, in order to conduct the movement, sometimes quicker, and sometimes slower, according to the kind of music, or the subject that is sung or played.

The measure is that which regulates the time we are to dwell on each note. See Time.

The ordinary or common measure is one second, or 60th part of a minute, which is nearly the space between the beats of the pulse or heart; the systole, or contraction of the heart, answering to the elevation of the hand; and its diastole, or dilatation, to the letting it fall. The measure usually takes up the space that a pendulum of two feet and a half long employs in making a swing or vibration. The measure is regulated according to the different quality or value of the notes in the piece; by which the time that each note is to take up is expressed. The semibreve, for instance, holds one rise and one fall; and this is called the *measure* or *whole measure*, sometimes the *measure note*, or *time note*; the minim, one rise, or one fall; and the crotchet, half a rise, or half a fall, there being four crotchets in a full measure.

Measure Binary, or *Double*, is that wherein the rise and fall of the hand are equal.

Measure Ternary, or *Triple*, is that wherein the fall is double to the rise; or where two minims are played during a fall, and but one in the rise. To this purpose, the number 3 is placed at the beginning of the lines, when the measure is intended to be triple; and a C, when the measure is to be common or double. This rising and falling of the hands was called by the Greeks αρσις and θεσις. St Augustine calls it *plausus*, and the Spaniards *compas*. See Arsis and Thesis.

Powder Measures in Artillery, are made of copper, and contain from an ounce to 12 pounds: these are very convenient in a siege, when guns or mortars are loaded with loose powder, especially in ricochet firing, &c.

Measure || Meat.

MEASURING, or Mensuration, is the using a certain known measure, and determining thereby the precise extent, quantity, or capacity of any thing.

Measuring, in general, includes the practical part of geometry. From the various subjects on which it is employed, it acquires various names, and constitutes various arts. See Geometry, Levelling, Mensuration, Trigonometry, &c.

MEAT. See Food, Diet, Drink, &c.

Amongst the Jews, several kinds of animals were forbidden to be used as food. The flesh with the blood, and the blood without the flesh, were prohibited; the fat also of sacrificed animals was not to be eaten. Roast meat, boiled meat, and ragouts, were in use among the Hebrews, but we meet with no kind of seasoning except salt, bitter herbs, and honey.—They never mingled milk in any ragout or hash, and never ate at the same meal both meat and milk, butter, or cheese. The daily provision for Solomon's table was 30 measures of fine wheat flour, 60 of common flour, 10 fat oxen, 20 pasture oxen, 100 sheep, besides venison and wildfowl. See Luxury.

The principal and most necessary food among the ancient Greeks, was bread, which they called αρτος, and produced in a wicker basket called κανεον. Their loaves were sometimes baked under the ashes, and sometimes in an oven. They also used a sort of bread called *maza*. Barley meal was used amongst the Greeks, which they called αλφιτον. They had a frequent dish called θριον, which was a composition of rice, cheese, eggs, and honey, wrapped in fig leaves. The μυττωτον was made of cheese, garlic, and eggs, beaten and mixed together. Their bread, and other substitutes for bread, were baked in the form of hollow plates, into which they poured a sauce. Garlic, onions, and figs, seem to have been a very common food amongst the poorer Athenians. The Greeks, especially in the heroical times, ate flesh roasted; boiled meat seldom was used. Fish seems not to have been used for food in the early ages of Greece. The young people only, amongst the Lacedæmonians, ate animal food; the men and the old men were supported by a black soup called μεγα ζωμος, which to people of other nations was always a disagreeable mess. Grasshoppers and the extremities or tender shoots of trees were frequently eaten by the poor among the Greeks. Eels dressed with beet root were esteemed a delicate dish, and they were fond of the jowl and belly of saltfish. Neither were they without their sweet-meats; the dessert consisted frequently of fruits, almonds, nuts, figs, peaches, &c. In every kind of food we find salt to have been used.

The diet of the first Romans consisted wholly of milk, herbs, and roots, which they cultivated and dressed with their own hands; they also had a kind of gruel, or coarse gross pap, composed of meal and boiling water; this served for bread: And when they began to use bread, they had none for a great while but of unmixed rye. Barley-meal was eaten by them, which they called *polenta*. When they began to eat animal food, it was esteemed a piece of luxury, and an indulgence not to be justified but by some particu-

 lar

Meat, Meath.

lar occasion. After animal food had grown into common use, the meat which they most frequently produced upon their tables was pork.

*Method of Preserving Flesh-*MEAT *without spices, and with very little salt.* Jones, in his *Miscellanea Curiosa*, gives us the following description of the Moorish *Elcholle*, which is made of beef, mutton, or camel's flesh, but chiefly beef, which is cut in long slices, and laid for 24 hours in a pickle. They then remove it out of those jars or tubs into others with water; and when it has lain a night, they take it out, and put it on ropes in the sun and air to dry. When it is thoroughly dried and hard, they cut it into pieces of two or three inches long, and throw it into a pan or caldron, which is ready with boiling oil and suet sufficient to hold it, where it boils till it be very clear and red when cut. After this they take it out, and set it to drain; and when all is thus done it stands to cool, and jars are prepared to put it up in, pouring upon it the liquor in which it was fried; and as soon as it is thoroughly cold, they stop it up close. It will keep two years; will be hard, and the hardest they look upon to be the best done. This they dish up cold, sometimes fried with eggs and garlic, sometimes stewed, and lemon squeezed on it. It is very good any way, either hot or cold.

MEATH, commonly so called, or otherwise *East* Meath, to distinguish it from the county called *West* Meath: A county of Ireland, in the province of Leinster, bounded by the counties of Cavan and Louth on the north, the Irish channel on the east, Kildare and Dublin on the south, and West Meath and Longford on the west. It is a fine champaign country, abounding with corn, and well inhabited. It returns two members to parliament; and gives title of earl to the family of Brabazan. It contains 326,480 Irish plantation acres, 139 parishes, and 112,000 inhabitants. The chief town is Trim. This district being the most ancient settlement of the Belgians in Ireland, the inhabitants were esteemed the eldest and most honourable tribe: from which seniority their chieftains were elected monarchs of all the Belgæ; a dignity that was continued in the Hy-n-Faillian without intermission, until the arrival of the Caledonian colonies, under the name of Tuath de Danan, when Conor-Mor, chieftain of these people, obtained, or rather usurped, the monarchal throne, obliged Eochy Failloch, with several of his people, to cross the Shannon, and establish themselves in the present county of Roscommon, where Crothar founded the palace of Atha or Croghan, a circumstance which brought on a long and bloody war between the Belgian and Caledonian races, which was not finally terminated until the close of the 4th century, when the Belgian line was restored in the person of O'Nial the Great, and continued until Briam Boromh usurped the monarchical dignity, by deposing Malachy O'Malachlin, about the year 1001. Tuathal Tetethomar, by a decree of the Tarah assembly, separated certain large tracts of land from each of the four provinces, where the borders joined together; whence, under the notion of adopting this spot for demesne lands to support the royal household, he formed the county or kingdom of Meath, which afterwards became the peculiar inheritance of the monarchs of Ireland. In each of the portions thus separated from the four provinces, Tuathal caused palaces to be erected, which might adorn them, and commemorate the name in which they had been added to the royal domain. In the tract taken out of Munster, he built the palace called Flachtaga, where the sacred fire, so called, was kindled, and where all the priests and druids annually met on the last day of October; on the evening of which day it was enacted, that no other fire should be used throughout the kingdom, in order that all the fires might be derived from this, which being lighted up as a fire of sacrifice, their superstition led them to believe would render all the rest propitious and holy; and for this privilege every family was to pay threepence, by way of acknowledgment to the king of Munster. The second royal palace was erected in the proportion taken out of Connaught, and was built for the assembly called the convocation of Visneach, at which all the inhabitants were summoned to appear on the 1st day of May, to offer sacrifice to *Beal*, or *Bel*, the god of fire, in whose honour two large fires being kindled, the natives used to drive their cattle between them, which was supposed to be a preservative for them against accidents and distempers, and this was called *Beal-Tinne*, or *Bel-Tine*, or the festival of the god of fire. The king of Connaught at this meeting claimed a horse and arms from every lord of a manor or chieftain, as an acknowledgment for the lands taken from that province, to add to the territory of Meath. The third was that which Tailtean erected in the part taken from Ulster, where the fair of that name was held, which was remarkable for this particular circumstance, that the inhabitants brought their children thither, males and females, and contracted them in marriage, where the parents having agreed upon articles, the young people were joined accordingly; every couple contracted at this meeting paid the king of Ulster an ounce of silver by way of acknowledgment. The royal mansion of Tarah, formerly destroyed by fire, being rebuilt by Tuathal, on the lands originally belonging to the king of Leinster, was reckoned as the fourth of these palaces; but as a fabric of that name had stood there before, we do not find that any acknowledgment was made for it to the king of Leinster.

Meath, with *Clonmacnois*, is a bishop's see, valued in the king's books at 373l. 7s. 0½d. sterling, by an extent returned anno 28th Elizabeth; but, by a former extent taken anno 30th Henry VIII. the valuation amounts to 373l. 12s. which being the largest and most profitable for the king, is the measure of the first fruits at this day. This see is reputed to be worth annually 3400l. There were formerly many episcopal sees in Meath, as Clonard, Duleck, Kells, Trim, Ardbraccan, Donshaghlin, Slaine, and Foure, besides others of less note; all these, except Dulcek and Kells, were consolidated, and their common see was fixed at Clonard, before the year 1152; at which time the divisions of the bishoprics in Ireland were made by John Paparo, cardinal priest, entitled Cardinal of St Lawrence in Damaso, then legate from Pope Eugene III. to the Irish. This division was made in a synod held on the 6th of March in the abbey of Mellifont, or, as some say, at Kells: and the two sees of Duleck and Kells afterwards submitted to the same fate. The constitution of this diocese is singular, having

Meath || Mecænas.

ing no dean nor chapter, cathedral, or œconomy.—Under the bishop, the archdeacon is the head officer, to whom, and to the clergy in general, the *conge d'elire* issued while bishops were elective. The affairs of the diocese are transacted by a synod, in the nature of a chapter, who have a common seal, which is annually lodged in the hands of one of the body, by the appointment and vote of the majority. The diocese is divided into twelve rural deaneries.

Of Clonmacnois, now annexed to Meath: There is no valuation of this see in the king's books; but it is supposed to be included in the extent of the see of Meath, taken anno 30th Henry VIII. The chapter of this see consisted anciently of dean, chanter, chancellor, treasurer, archdeacon, and twelve prebendaries, but most of their possessions have fallen into lay hands. At present the deanery is the only part of the chapter which subsists, to which the prebend of Cloghran is annexed, and he hath a seal of office, which appears to have been the ancient episcopal seal of this see. This see was founded by St Kiaran, or Ciaran, the younger, in 548 or 549; and Dermod, the son of Ceronill, king of Ireland, granted the site on which the church was built.

West Meath. See Westmeith.

MEATUS auditorius. See Anatomy, N° 144.

MEAUX, an ancient town of France, in the department of the Seine and Marne, with a bishop's see, seated in a place abounding in corn and cattle, on the river Marne, which divides it into two parts; and its trade consists in corn, wool, and cheese. It sustained a siege of three months against the English in 1421. E. Long. 2. 58. N. Lat. 48. 58.

MECÆNAS, or Mecoenas, C. Cilnius, a celebrated Roman knight, descended from the kings of Etruria. He has rendered himself immortal by his liberal patronage of learned men and of letters; and to his prudence and advice Augustus acknowledged himself indebted for the security he enjoyed. His fondness for pleasure removed him from the reach of ambition; and he preferred dying, as he was born, a Roman knight, to all the honours and dignities which either the friendship of Augustus or his own popularity could heap upon him. To the interference of Mecænas, Virgil owed the retribution of his lands; and Horace was proud to boast that his learned friend had obtained his forgiveness from the emperor, for joining the cause of Brutus at the battle of Philippi. Mecænas was himself fond of literature: and, according to the most received opinion, he wrote a history of animals, a journal of the life of Augustus, a treatise on the different natures and kinds of precious stones, besides the two tragedies of Octavia and Prometheus, and other things, all now lost. He died eight years before Christ; and on his deathbed he particularly recommended his poetical friend Horace to the care and confidence of Augustus. Seneca, who has liberally commended the genius and abilities of Mecænas, has not withheld his censure from his dissipation, indolence, and effeminate luxury. From the patronage and encouragement which the princes of heroic and lyric poetry among the Latins received from the favourite of Augustus, all patrons of literature have ever since been called *Mecænates*. Virgil dedicated to him his Georgics, and Horace his Odes.

Mecca.

MECCA, an ancient and very famous town of Asia, in Arabia Felix; seated on a barren spot, in a valley surrounded with little hills, about a day's journey from the Red sea. It is a place of no strength, having neither walls nor gates; and the buildings are very mean. That which supports it is the resort of a great many thousand pilgrims annually, for the shops are scarcely open all the year besides. The inhabitants are poor, very thin, lean, and swarthy. The hills about the town are very numerous; and consist of a blackish rock, some of them half a mile in circumference. On the top of one of them is a cave, where they pretend Mahomet usually retired to perform his devotions, and hither they affirm the greatest part of the Alcoran was brought him by the angel Gabriel. The town has plenty of water, and yet little garden-stuff; but there are several sorts of good fruits to be had, such as grapes, melons, water melons, and cucumbers. There are also plenty of sheep brought thither to be sold to the pilgrims. It stands in a very hot climate; and the inhabitants usually sleep on the tops of their houses for the sake of coolness. In order to protect themselves from the heat through the day, they carefully shut the windows, and water the streets to refresh the air. There have been instances of persons suffocated in the middle of the town by the burning wind called *Simoom*.

As a great number of the people of distinction in the province of Hedsjas stay in the city, it is better built than any other in Arabia. Amongst the beautiful edifices it contains, the most remarkable is the famous *Kaba* or *Caaba*, "The house of God," which was held in great veneration by the Arabs even before Mahomet's time,

No Christian dares go to Mecca; not that the approach to it is prohibited by any express law, or that the sensible part of the Mahometans have any thi g to object to it; but on account of the prejudices of the people, who regarding this ground as sacred, th nk Christians unworthy of setting their foot on it; it would be profaned in the opinion of the superstious, if it was trod upon by infidels. The people even believe, that Christians are prevented from approaching by some supernatural power; and they tell the story of an infidel, who having got so far as the hills that surround Mecca, all the dogs of the city came out and fell upon him; and who, being struck with this miracle, and the august appearance of the Kaba, immediately became a mussulman. It is therefore to be presumed that all the Europeans who describe Mecca as eye-witnesses, have been renegadoes escaped from Turkey. A recent example confirms this supposition. On the promise of being allowed to preserve his religion, a French surgeon was prevailed on to accompany the Emir Hadsji to Mecca, in quality of physician; but at the very first station, he was forced to submit to circumcision, and then he was permitted to continue his journey.

Although the Mahometans do not allow Europeans to go to Mecca, they do not refuse to give them descriptions of the Kaba, and information with regard to that building; and there are persons who gain their bread by making designs and little pictures of the Kaba, and selling them to pilgrims. See Caaba.

The Mahometans have so high an opinion of the sanctity

Mecca.

sanctity of Mecca, that they extend it to the places in the neighbourhood. The territory of that city is held sacred to certain distances, which are indicated by particular marks. Every caravan finds in its road a similar mark, which gives notice to the pilgrims when they are to put on the modest garb in which they must appear in those sacred regions. Every mussulman is obliged to go once in his life at least to Mecca, to perform his devotions there. If that law was rigourously enforced, the concourse of pilgrims would be prodigious, and the city would never be able to contain the multitudes from all the countries where the Mahometan religion prevails. We must therefore, suppose, that devotees alone perform this duty, and that the others can easily dispense with it. Those whose circumstances do not permit a long absence, have the liberty of going to Mecca by a substitute.—A hired pilgrim, however, cannot go for more than one person at a time; and he must, to prevent frauds, bring an attestation in proper form, from an imam of Mecca, that he has performed the requisite devotions on behalf of such a person, either alive or dead; for, after the decease of a person who has not obeyed the law during his life, he is still obliged to perform the journey by proxy.

The caravans, which are not numerous, when we consider the immense multitude of the faithful, are composed of many people who do not make the journey for purposes of devotion. These are merchants, who think they can transport their merchandises with more safety, and dispose of them more easily; and contractors of every kind, who furnish the pilgrims and the soldiers who escort the caravans, with necessaries. Thus it happens, that many people have gone often to Mecca, solely from views of interest. The most considerable of those caravans is that of Syria, commanded by the pacha of Damascus. It joins at some distance the second from Egypt, which is conducted by a bey, who takes the title of Emir Hadsji. One comes from Yemen, and another, less numerous, from the country of Lachsa. Some scattered pilgrims arrive by the Red sea from the Indies, and from the Arabian establishments on the coasts of Africa. The Persians come in that which departs from Bagdad; the place of conductor to this last is bestowed by the pacha, and is very lucrative, for he receives the ransoms of the heretical Persians.

It is of consequence to a pilgrim to arrive early at the holy places. Without having been present from the beginning at all the ceremonies, and without having performed every particular act of devotion, a man cannot acquire the title of Hadsji: this is an honour very much coveted by the Turks, for it confers real advantages, and makes those who attain it to be much respected. Its infrequency, however, in the Mahometan dominions, shows how much the observation of the law commanding pilgrimages is neglected. A similar custom prevails among the Oriental Christians, who are exceedingly emulous of the title of Hadsji, or Mokdasi, which is given to pilgrims of their communion. In order to acquire this title, it is not sufficient that the person has made the journey to Jerusalem; he must also have kept the passover in that city, and have assisted at all the ceremonies of the holy weeks.

After all the essential ceremonies are over, the pilgrims next morning move to a place where they say Abraham went to offer up his son Isaac, which is about two or three miles from Mecca: here they pitch their tents, and then throw seven small stones against a little square stone building. This, as they affirm, is performed in defiance of the devil. Every one then purchases a sheep, which is brought for that purpose, eating some of it themselves, and giving the rest to the poor people who attend upon that occasion. Indeed these are miserable objects, and such starved creatures, that they seem ready to devour each other. After all, one would imagine that this was a very sanctified place; and yet a renegado who went in pilgrimage thither, affirms there is as much debauchery practised here as in any part of the Turkish dominions. It is 25 miles from Jodda, the sea port town of Mecca, and 220 south-east of Medina. E. Long. 40. 55. N. Lat. 21. 45.

Mecca, Mechanical.

MECHANICAL, an epithet applied to whatever relates to mechanics: Thus we say, mechanical powers, causes, &c. See the articles Power, Cause, &c.

The mechanical philosophy is the same with what is otherwise called *corpuscular philosophy*, which explains the phenomena of nature, and the operations of corporeal things, on the principles of mechanics; viz. the motion, gravity, arrangement, disposition, greatness or smallness, of the parts which compose natural bodies. See Corpuscular.

This manner of reasoning is much used in medicine; and, according to Dr Quincy, is the result of a thorough acquaintance with the structure of animal bodies: for considering an animal body as a composition out of the same matter from which all other bodies are formed, and to have all those properties which concern a physician's regard, only by virtue of its peculiar construction; it naturally leads a person to consider the several parts, according to their figures, contexture, and use, either as wheels, pulleys, wedges, levers, screws, cords, canals, strainers, &c. For which purpose, continues he, it is frequently found helpful to design in diagrams, whatsoever of that kind is under consideration, as is customary in geometrical demonstrations.

For the application of this doctrine to the human body, see the article Medicine.

Mechanical, in mathematics, denotes a construction of some problem, by the assistance of instruments, as the duplicature of the cube and quadrature of the circle, in contradistinction to that which is done in an accurate and geometrical manner.

Mechanical Curve, is a curve, according to Descartes, which cannot be defined by any algebraic equation; and so stands contradistinguished from algebraic or geometrical curves.

Leibnitz and others call these mechanical curves *transcendental*, and dissent from Descartes, in excluding them out of geometry. Leibnitz found a new kind of transcendental equations, where these curves are defined: but they do not continue constantly the same in all points of the curve, as algebraic ones do. See the article Transcendental.

Mechanical Solution of a problem is either when the thing is done by repeated trials, or when lines used in

Mechanical. in the solution are not truly geometrical, or by organical construction.

Mechanical Powers, are certain simple machines, which are used for raising greater weights; or overcoming greater resistances, than could be effected by the natural strength without them. See MECHANICS.

MECHANICS.

Definition. 1. MECHANICS is the science which enquires into the laws of the equilibrium and motion of solid bodies; into the forces by which bodies, whether animate or inanimate, may be made to act upon one another; and into the means by which these may be increased so as to overcome such as are most powerful.—The term *mechanics* was originally applied to the doctrine of equilibrium. It has by some late writers been extended to the motion and equilibrium of all bodies, whether solid, fluid, or aëriform; and has been employed to comprehend the sciences of hydrodynamics and pneumatics.

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Progress of practical mechanics among the ancients. 2. As the science of mechanics is intimately connected with the arts of life, and particularly with those which exist even in the rudest ages of society, the construction of machines must have arrived at considerable perfection before the theory of equilibrium, or the simplest properties of the mechanical powers, had engaged the attention of philosophers. We accordingly find that the lever, the pulley, the crane, the capstan, and other simple machines, were employed by the ancient architects in elevating the materials of their buildings, long before the dawn of mechanical science; and the military engines of the Greeks and Romans, such as the catapultæ and balistæ, exhibit an extensive acquaintance with the construction of compound machinery. In the splendid remains of Egyptian architecture, which in every age have excited the admiration of the world, we perceive the most surprising marks of mechanical genius. The elevation of immense masses of stone to the tops of their stupendous fabrics, must have required an accumulation of mechanical power which is not in the possession of modern architects.

Aristotle the first who attended to the theory of mechanics. A. C. 320. 3. The earliest traces of any thing like the theory of mechanics are to be found in the writings of Aristotle. In some of his works we discover a few erroneous and obscure opinions, respecting the doctrine of motion, and the nature of equilibrium; and in his 28th mechanical question he has given some vague observations on the force of impulse, tending to point out the difference between impulse and pressure. He maintained that there cannot be two circular motions opposite to one another; that heavy bodies descended to the centre of the universe, and that the velocities of their descent were proportional to their weights.

Archimedes lays the foundation of theoretical mechanics. A. C. 250. 4. The notions of Aristotle, however, were so confused and erroneous, that the honour of laying the foundation of theoretical mechanics is exclusively due to the celebrated Archimedes, who, in addition to his inventions in geometry, discovered the general principles of hydrostatics. In his two books, *De Equiponderantibus*, he has demonstrated that when a balance with unequal arms, is in equilibrio, by means of two weights in its opposite scales, these weights must be reciprocally proportional to the arms of the balance. From this general principle, all the other properties of the lever, and of machines referable to the lever, might have been deduced as corollaries; but Archimedes did not follow the discovery through all its consequences. In demonstrating the leading property of the lever, he lays it down as an axiom, that if the two arms of the balance are equal, the two weights must also be equal when an equilibrium takes place; and then shows that if one of the arms be increased, and the equilibrium still continue, the weight appended to that arm must be proportionally diminished. This important discovery conducted the Syracusan philosopher to another equally useful in mechanics. Reflecting on the construction of his balance, which moved upon a fulcrum, he perceived that the two weights exerted the same pressure on the fulcrum as if they had both rested upon it. He then considered the sum of these two weights as combined with a third, and the sum of these three as combined with a fourth; and saw that in every such combination the fulcrum must support their united weight, and therefore that there is in every combination of bodies, and in every single body which may be conceived as made up of a number of lesser bodies, *a centre of pressure or gravity*. This discovery Archimedes applied to particular cases, and pointed out the method of finding the centre of gravity of plane surfaces, whether bounded by a parallelogram, a triangle, a trapezium, or a parabola. The theory of the inclined plane, the pulley, the axis in peritrochio, the screw, and the wedge, which was first published in the eighth book of Pappus's mathematical collections, is generally attributed to Archimedes. It appears also from Plutarch and other ancient authors, that a greater number of machines which have not reached our times was invented by this philosopher. The military engines which he employed in the siege of Syracuse against those of the Roman engineer Appius, are said to have displayed the greatest mechanical genius, and to have retarded the capture of his native city.

5. Among the various inventions which we have received from antiquity, that of water mills is entitled to the highest place, whether we consider the ingenuity which they display, or the useful purposes to which they are subservient. In the infancy of the Roman republic the corn was ground by hand-mills, consisting of two millstones, one of which was moveable, and the other at rest. The upper millstone was made to revolve either by the hand applied directly to a winch, or by means of a rope winding round a capstan. The precise time when the impulse or the weight of water was substituted in the place of animal labour, is not exactly known. From an epigram in the *Anthologia Græca*, there is reason to believe that water-mills were invented during the reign of Augustus; but it is strange that in the Invention of water-mills and wind-mills.

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the description given of them by Vitruvius, who lived under that emperor, they are not mentioned as of recent origin. The invention of wind-mills is of a later date. According to some authors, they were first used in France in the sixth century; while others maintain that they were brought to Europe in the time of the crusades, and that they had long been employed in the east, where the scarcity of water precluded the application of that agent to machinery.

Stevinus discovers the parallelogram of forces. Died in 1635.

6. The science of mechanics seems to have been stationary till the end of the 16th century. In 1577 a treatise on mechanics was published by Guidus Ubaldus, but it contained merely the discoveries of Archimedes. Simon Stevinus, however, a Dutch mathematician, contributed greatly to the progress of the science. He discovered the parallelogram of forces; and has demonstrated in his Statics, published in 1586, that if a body is urged by two forces in the direction of the sides of a parallelogram and proportional to these sides, the combined action of these two forces is equivalent to a third force acting in the direction of the diagonal of the parallelogram, and having its intensity proportional to that diagonal. This important discovery, which has been of such service in the different departments of physics, should have conferred upon its author a greater degree of celebrity than he has actually enjoyed. His name has scarcely been enrolled in the temple of fame, but justice may yet be done to the memory of such an ingenious man. He had likewise the merit of illustrating other parts of statics; and he appears to have been the first who, without the aid of the properties of the lever, discovered the laws of equilibrium in bodies placed on an inclined plane. His works were reprinted in the Dutch language in 1605. They were translated into Latin in 1608, and into French in 1634; and in these editions of his works his Statics were enlarged by an appendix, in which he treats of the rope machine, and on pulleys acting obliquely.

Lucas Valerius writes on the centre of gravity of solids. 1661.

7. The doctrine of the centre of gravity, which had been applied by Archimedes only to plane surfaces, was now extended by Lucas Valerius to solid bodies. In his work entitled *De Centro Gravitatis Solidorum Liber*, published at Bologna in 1661, he has discussed this subject with such ability, as to receive from Galileo the honourable appellation of the *Novus nostræ ætatis Archimedes*.

Discoveries of Galileo. Born 1564. Died 1642.

8. In the hands of Galileo the science of mechanics assumed a new form. In 1572 he wrote a small treatise on statics, which he reduced to this principle, that it requires an equal power to raise two different bodies to altitudes in the inverse ratio of their weights, or that the same power is requisite to raise 10 pounds to the height of 100 feet, and 20 pounds to the height of 50 feet. This fertile principle was not pursued by Galileo to its different consequences. It was left to Descartes to apply it to the determination of the equilibrium of machines, which he did in his explanation of machines and engines, without acknowledging his obligations to the Tuscan philosopher. In addition to this new principle, Galileo enriched mechanics with his theory of local motion. This great discovery has immortalized its author; and whether we consider its intrinsic value, or the change which it produced on the physical sciences, we are led to regard it as nearly of equal importance with the theory of universal gravitation, to which it paved the way. The first hints of this new theory were given in his Systema Cosmicum, *Dialogus* II. The subject was afterwards fully discussed in another, entitled *Discursus et Demonstrationes Mathematicæ circa duas novas Scientias pertinentes ad Mechanicam et Motum Localem*, and published in 1638. This work is divided into four dialogues; the first of which treats of the resistance of solid bodies before they are broken: The second points out the cause of the cohesion of solids. In the third he discusses his theory of local motions, comprehending those which are equable, and those which are uniformly accelerated. In the fourth he treats of violent motion, or the motion of projectiles; and in an appendix to the work he demonstrates several propositions relative to the centre of gravity of solid bodies. In the first of these dialogues he has founded his reasoning on principles which are far from being correct, but he has been more successful in the other three. In the third dialogue, which contains his celebrated theory, he discusses the doctrine of equable motions in six theorems, containing the different relations between the velocity of the moving body, the space which it describes, and the time employed in its description. In the second part of the dialogue, which treats of accelerated motion, he considers all bodies as heavy, and composed of a number of parts which are also heavy. Hence he concludes that the total weight of the body is proportional to the number of the material particles of which it is composed, and then reasons in the following manner. As the weight of a body is a power always the same in quantity, and as it constantly acts without interruption, the body must be continually receiving from it equal impulses in equal and successive instants of time. When the body is prevented from falling by being placed on a table, its weight is incessantly impelling it downwards, but these impulses are incessantly destroyed by the resistance of the table which prevents it from yielding to them. But where the body falls freely, the impulses which it perpetually receives are perpetually accumulating, and remain in the body unchanged in every respect excepting the diminution which they experience from the resistance of air. It therefore follows, that a body falling freely is uniformly accelerated, or receives equal increments of velocity in equal times. Having established this as a definition, he then demonstrates, that the time in which any space is described by a motion uniformly accelerated from rest, is equal to the time in which the same space would be described by an uniform equable motion with half the final velocity of the accelerated motion; and that in every motion uniformly accelerated from rest, the spaces described are in the duplicate ratio of the times of description. After having proved these theorems, he applies the doctrine with great success to the ascent and descent of bodies on inclined planes.

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Labours of Torricelli. 1644.

9. The theory of Galileo was embraced by his pupil Torricelli, who illustrated and extended it in his excellent work entitled *De motu gravium naturaliter accelerato*, published in 1664. In his treatise *De motu projectorum*, published in the Florentine edition of his works, in 1664, he has added several new and important propositions to those which were given by his master on the motion of projectiles.

Invention of the steam engine.

10. It was about this time that steam began to be employed

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employed as the first mover of machinery. This great discovery has been ascribed by the English to the marquis of Worcester, and to Papin by the French; but it is almost certain, that about 34 years before the date of the marquis's invention, and about 61 years before the construction of Papin's digester, steam was employed as the impelling power of a stamping engine by one Brancas an Italian, who published an account of his invention in 1629. It is extremely probable, however, that the marquis of Worcester had never seen the work of Brancas, and that the fire-engine which he mentions in his Century of Inventions was the result of his own ingenuity. The advantages of steam as an impelling power being thus known, the ingenious Captain Savary invented an engine which raised water by the expansion and condensation of steam. Several engines of this construction were actually erected in England and France, but they were incapable of raising water from depths which exceeded 35 feet. The steam-engine received great improvements from our countrymen Newcomen, Brighton, and Blakey; but it was brought to it present state of perfection by Mr Watt of Birmingham, one of the most accomplished engineers of the present age. Hitherto it had been employed merely as a hydraulic machine for draining mines or raising water, but in consequence of Mr Watt's improvements it has long been used as the impelling power of almost every species of machinery. It is a curious circumstance, that the steam-engine was not only invented, but has received all its improvements, in our own country.

Discoveries of Huygens. 1673.

11. The success of Galileo in investigating the doctrine of rectilineal motion, induced the illustrious Huygens to turn his attention to curvilineal motion. In his celebrated work *De Horologio Oscillatorio*, published in 1673, he has shown that the velocity of a heavy body descending along any curve, is the same at every instant in the direction of the tangent, as it would have been if it had fallen through a height equal to the corresponding vertical absciss; and from the application of this principle to the reversed cycloid with its axis vertical, he discovered the isochronism of the cycloid, or that a heavy body, from whatever part of the cycloid it begins to fall, always arrives at the lower point of the curve in the same space of time. By these discussions, Huygens was gradually led to his beautiful theory of central forces in the circle. This theory may be applied to the motion of a body in any curve, by considering all curves as composed of an infinite number of small arcs of circles of different radii, which Huygens had already done in his theory of evolutes. The theorems of Huygens concerning the centrifugal force and circular motions, were published without demonstrations.
1700. They were first demonstrated by Dr Keill at the end of his Introduction to Natural Philosophy. The demonstrations of Huygens, however, which were more prolix than those of the English philosopher, were afterwards given in his posthumous works.

The laws of collision discovered by Wallis, Huygens, and Wren. 1661.

12. About this time the true laws of collision or percussion were separately discovered by Wallis, Huygens, and Sir Christopher Wren in 1661, without having the least communication with each other. They were transmitted to the Royal Society of London in 1688, and appeared in the 43d and 46th numbers of their Transactions. The rules given by Wallis and Wren are published in N° 43, pp. 864 and 867, and those of Huygens in N° 46, p. 927. The foundation of all their solutions is, that in the mutual collision of bodies, the absolute quantity of motion of the centre of gravity is the same after impact as before it, and that when the bodies are elastic, the respective velocity is the same after as before the shock.—We are indebted likewise to Sir Christopher Wren for an ingenious method of demonstrating the laws of impulsion by experiment. He suspended the impinging bodies by threads of equal length, so that they might touch each other when at rest. When the two bodies were separated from one another, and then allowed to approach by their own gravity, they impinged against each other when they arrived at the positions which they had when at rest, and their velocities were proportional to the chords of the arches through which they had fallen. Their velocities after impact were also measured by the chords of the arches through which the stroke had forced them to ascend, and the results of the experiments coincided exactly with the deductions of theory. The laws of percussion were afterwards more fully investigated by Huygens, in his posthumous work *De Motu Corporum ex Percussione*, and by Wallis in his *Mechanica*, published in 1670.

Mechanical problems proposed by Mersennus. 1635.

13. The attention of philosophers was at this time directed to the two mechanical problems proposed by Mersennus in 1635. The first of these problems was to determine the centre of oscillation in a compound pendulum, and the second to find the centre of percussion of a single body, or a system of bodies turning round a fixed axis. The centre of oscillation is that point in a compound pendulum, or a system of bodies moving round a centre, in which, if a small body were placed and made to move round the same centre, it would perform its oscillations in the same time as the system of bodies. The centre of percussion, which is situated in the same point of the system as the centre of oscillation, is that point of a body revolving or vibrating about an axis, which being struck by an immoveable obstacle, the whole of its motion is destroyed.

Huygens solves the problem of the centre of oscillation.

These two problems were at first discussed by Descartes and Roberval, but the methods which they employed were far from being correct. The first solution of the problem on the centre of oscillation was given by Huygens. He assumed as a principle, that if several weights attached to a pendulum descended by the force of gravity, and if at any instant the bodies were detached from one another, and each ascended with the velocity it had acquired by its fall, they would rise to such a height that the centre of gravity of the system in that state would descend to the same height as that from which the centre of gravity of the pendulum had descended. The solution founded on this principle, which was not derived from the fundamental laws of mechanics, did not at first meet with the approbation of philosophers; but it was afterwards demonstrated in the clearest manner, and now forms the principle of the conservation of active forces.—The problem of the centre of percussion was not attended with such difficulties. Several incomplete solutions of it were given by different geometers; but it was at last resolved in an accurate and general manner by James Bernouilli by the principle of the lever.

Works of Borelli. 1666

14. In 1666, a treatise *De Vi Percussionis*, was published

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1686.

lished by J. Alphonso Borelli, and in 1686, another work, *De Motionibus Naturalibus à Gravitate Pendentibus*; but he added nothing to the science of mechanics. His ingenious work, *De Motu Animalium*, however, is entitled to great praise, for the beautiful application which it contains of the laws of statics to explain the various motions of living agents.

Labours of Varignon.

15. The application of statics to the equilibrium of machines, was first made by Varignon in his Project of a new System of Mechanics, published in 1687. The subject was afterwards completely discussed in his *Nouvelle Mecanique*, a posthumous work published in 1725. In this work are given the first notions of the celebrated principle of virtual velocities, from a letter of John Bernouilli's to Varignon in 1717. The virtual velocity of a body is the infinitely small space, through which the body excited to move has a tendency to describe in one instant of time. This principle has been successfully applied by Varignon to the equilibrium of all the simple machines. The resistance of solids, which was first treated by Galileo, was discussed more correctly by Leibnitz in the *Acta Eruditorum* for 1687. In the Memoirs of the Academy for 1702, Varignon has taken up the subject, and rendered the theory much more universal.

Parent on the maximum effect of machines.

16. An important step in the construction of machinery was about this time made by Parent. He remarked in general that if the parts of a machine are so arranged, that the velocity of the impelling power becomes greater or less according as the weight put in motion becomes greater or less, there is a certain proportion between the velocity of the impelling power, and that of the weight to be moved, which renders the effect of the machine a *maximum* or a *minimum* *. He then applies this principle to undershot wheels, and shows that a maximum effect will be produced when the velocity of the stream is equal to *thrice* the velocity of the wheel. In obtaining this conclusion, Parent supposed that the force of the current upon the wheel is in the duplicate ratio of the relative velocity, which is true only when a single floatboard is impelled by the water. But when more floatboards than one are acted upon at the same time, it is obvious that the momentum of the water is directly as the relative velocity; and by making this substitution in Parent's demonstration, it will be found that a maximum effect is produced when the velocity of the current is double that of the wheel. This result was first obtained by the Chevalier Borda, and has been amply confirmed by the experiments of Smeaton. (See HYDRODYNAMICS, § 279, 280, 281.) The principle of Parent was also applied by him to the construction of windmills. It had been generally supposed that the most efficacious angle of weather was 45°; but it was demonstrated by the French philosopher that a maximum effect is produced when the sails are inclined $54\frac{3}{7}$ degrees to the axis of rotation, or, when the angle of weather is $35\frac{1}{7}$ degrees. This conclusion, however, is subject to modifications which will be pointed out in a subsequent part of this article.

* *Mem. de l'Acad.* 1704.

De la Hire writes on the teeth of wheels.

17. The *Traite de Mecanique* of De la Hire, published separately in 1695, and in the 9th volume of the Memoirs of the French Academy from 1666 to 1699, contains the general properties of the mechanical powers, and the description of several ingenious and useful machines. But it is chiefly remarkable for the *Traite des Epicycloides*, which is added to the edition published in the Memoirs of the Academy. In his interesting treatise, De la Hire considers the genesis and properties of exterior and interior epicycloids, and demonstrates, that when one wheel is employed to drive another, the one will move sometimes with greater and sometimes with less force, and the other will move sometimes with greater and sometimes with less velocity, unless the teeth of one or both of the wheels be parts of a curve generated like an epicycloid. The same truth is applicable to the formation of the teeth of rackwork, the arms of levers, the wipers of stampers, and the lifting cogs of forge hammers; and as the epicycloidal teeth when properly formed roll upon one another without much friction, the motion of the machine will be uniform and pleasant, its communicating parts will be prevented from wearing, and there will be no unnecessary waste of the impelling power. Although De la Hire was the first who published this important discovery, yet the honour of it is certainly due to Olaus Roemer, the celebrated Danish astronomer, who discovered the successive propagation of light. It is expressly stated by Leibnitz *, in his letters to John Bernouilli, that Roemer communicated to him the discovery 20 years before the publication of De la Hire's work; but still we have no ground for believing that De la Hire was guilty of plagiarism. Roemer's researches were not published; and from the complete discussion which the subject has received from the French philosopher, it is not unlikely that he had the merit of being the second inventor. Even Camus †, who about 40 years afterwards gave a complete and accurate theory of the teeth of wheels, was unacquainted with the pretensions of Roemer, and ascribes the discovery to De la Hire.

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The discovery of epicycloidal teeth first made by Roemer.

* *Miscellan. Berolinens.* 1710. p. 315.

† *Cours de Mathematique*, Liv. x. et xi.

Discoveries of Newton.

18. The publication of Newton's Principia contributed greatly to the progress of mechanics. His discoveries concerning the curvilineal motion of bodies, combined with the theory of universal gravitation, enabled philosophers to apply the science of mechanics to the phenomena of the heavens, to ascertain the law of the force by which the planets are held in their orbits, and to compute the various irregularities in the solar system, which arise from the mutual action of the bodies which compose it. The *Mecanique Celeste* of La Place will be a standing monument of the extension which mechanics has received from the theory of gravity. The important mechanical principle of the conservation of the motion of the centre of gravity is also due to Newton. He has demonstrated in his Principia, that the state of the centre of gravity of several bodies, whether in a state of rest or motion, is not affected by the reciprocal action of these bodies, whatever it may be, so that the centre of gravity of the bodies which act upon one another, either by the intervention of levers, or by the laws of attraction, will either remain at rest, or move uniformly in a right line.

Principle of the conservation of active forces first discovered by Huygens.

19. We have already seen that the principle of the conservation of active forces was discovered by Huygens when he solved the problem of the centre of oscillation. The principle alluded to consists in this, that in all the actions of bodies upon each other, whether that action consists in the percussion of elastic bodies, or is communicated from one body to another by threads or inflexible rods, the sums of the masses multiplied by the squares of the absolute velocities remain always the same. This

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This important law is easily deducible from two simpler laws admitted in mechanics. 1. That in the collision of elastic bodies, their respective velocities remain the same after impact as they were before it; and, 2. That the quantity of action, or the product of the masses of the impinging bodies, multiplied by the velocity of their centre of gravity, is the same after as before impact. The principle of the conservation of active forces, was regarded by its inventor only as a simple mechanical theorem. John Bernouilli, however, considered it as a general law of nature, and applied it to the solution of several problems which could not be resolved by direct methods; but his son Daniel deduced from it the laws of the motion of fluids from vessels, a subject which had been formerly treated in a very vague manner. He afterwards rendered the principle more general *, and showed how it could be applied to the motion of bodies influenced by their mutual attractions, or solicited towards fixed centres by forces proportional to any function of the distance.

Rendered general by Daniel Bernouilli.

* Mem. de l'Acad. Berlin, 1748.

Daniel Bernouilli and other philosophers demonstrate the parallelogram of forces.

20. After the parallelogram of forces had been introduced into statics by Stevinus, it was generally admitted upon the same demonstration which was given for the composition of motion. The first complete demonstration was given by Daniel Bernouilli in the Commentaries of Petersburgh for 1726, independent of the consideration of compound motion. This demonstration, which was both long and abstruse, was greatly simplified by D'Alembert in the Memoirs of the Academy for 1769. Fonseneix and Riccati have given a very ingenious one in the Memoirs of the Academy of Turin for 1761. This was also improved by D'Alembert, who gave another in the same Memoirs, and a third in his *Traité de Dynamique*, published in 1743. Dr Robison † has combined the demonstrations of Bernouilli and D'Alembert with one by Frisi, and produced one that is more expeditious and simple. La Place has likewise given a demonstration of the parallelogram of forces in his *Mecanique Celeste*.

† Sup. Encycl. § Dynamics.

Dispute about the measure of active forces.

21. About the beginning of the 18th century, the celebrated dispute about the measure of active forces was keenly agitated among philosophers. The first spark of this war, which for 40 years England maintained single-handed against all the genius of the continent, was excited by Leibnitz. In the Leipsic acts for 1686, he asserted that Descartes was mistaken in making the force of bodies proportional to their simple velocity, and maintained that it followed the ratio of the square of the velocity. He shewed, that a body, with a velocity of two feet, acquires the power of raising itself to a height four times as great as that to which a body could rise with a velocity of only one foot; and hence he concludes, that the force of that body is as the square of its velocity. The abbé de Cotilon, a zealous Cartesian, allowed the premises of Leibnitz, but denied his conclusion. The body, said he, which moves with a velocity of two feet, will certainly rise to quadruple the height of another body that has only the velocity of one foot; but it will take *twice the time* to rise to that height, and a quadruple effect, in a double time, is not a quadruple force, but only a double one. The theory of Leibnitz was supported by John Bernouilli, Herman, Gravesende, Muschenbroeck, Poleni, Wolff, and Bulfinger; and the opinion of Descartes by Maclaurin, Stirling, Clarke, Desaguliers, and other English philosophers. The question was at last involved in metaphysical reasoning; and if the dispute did terminate in favour of either party, the English philosophers were certainly victorious. It appears, in the clearest manner, that the force of a moving body, indicated by the space which it describes, is as the simple velocity, if we consider the space as described in a determinate time; but it is as the square of the velocity, if we do not consider the time in which the space is described. The question, therefore, comes to be this: In estimating the forces of bodies in motion, ought we to take time into consideration? If, with the followers of Leibnitz, we reject this element, then we may maintain that the force of a child is equal to that of a man carrying a load, because the child is also capable of carying the same load, though in small parts and in a greater length of time.

D'Alembert's principle of dynamics.

22. In 1743, D'Alembert published his *Traité de Dynamique*, founded upon a new principle in mechanics. This principle was first employed by James Bernouilli in his solution of the problem of the centre of oscillation; but D'Alembert had the honour of generalising it, and giving it all that simplicity and fertility of which it was susceptible. He showed, that in whatever manner the bodies of one system act upon another, their motions may always be decomposed into two others at every instant, those of the one being destroyed the instant following, and those of the other retained, and that the motions retained are necessarily known from the conditions of equilibrium between those which are destroyed. This principle is evidently a consequence of the laws of motion and equilibrium, and has the advantage of reducing all the problems of dynamics to pure geometry and the principles of statics. By means of it D'Alembert has resolved a number of beautiful problems which had escaped his predecessors, and particularly that of the precession of the equinoxes, which had occupied the attention of Newton. In his *Traité de Dynamique*, D'Alembert has likewise reduced the whole of mechanics to three principles, the force of inertia, compound motion, and equilibrium; and has illustrated his views on this subject by that profound and luminous reasoning which characterises all his writings.

Euler, Daniel Bernouilli, and d'Arcy, discover the conservation of the momentum of rotatory motion.

23. Another general principle in dynamics was about this time discovered separately by Euler, Daniel Bernouilli, and the chevalier D'Arcy, and received the name of *conservation of the momentum of rotatory motion*. According to the two first philosophers, the principle may be thus defined: In the motion of several bodies round a fixed centre, the sum of the products of the mass of each body multiplied by the velocity of its motion round the centre, and by its distance from that centre, is always independent of the mutual action which the bodies may exert upon each other, and always preserves itself the same, provided the bodies are not influenced by any external cause. This principle was given by Daniel Bernouilli in the Memoirs of the Academy of Berlin for 1746; and the same year by Euler in the first volume of his works. They were both led to the discovery, while investigating the motion of several bodies in a tube of a given form, and which can only turn round a fixed point. The principle discovered by the chevalier D'Arcy was given in a memoir dated 1746, and published in the Memoirs of the

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the Academy for 1747. He shewed, that the sum of the products of the mass of each body by the area which its radius vector describes round a fixed point, is always proportional to the times. The identity of this principle, which is a generalisation of Newton's theorem about the areas described by the planetary bodies, with that of Euler and Bernouilli, will be easily perceived, if we consider that the element of the circular arc, divided by the element of the time, expresses the velocity of circulation, and that the element of the circular arc, multiplied by the distance from the centre, gives the element of the area described round that centre; so that the principle of Euler is only a differential expression of the principle of D'Arcy, which he afterwards expressed in this form, that the sum of the products of the masses of each body by their velocities, and by the perpendiculars drawn from the centre to their lines of direction, is a constant quantity.

The principle of least action proposed by Maupertuis.

24. The principle of least action, which was first proposed by Maupertuis in 1744, consists in this, that when several bodies, acting upon one another, experience any change in their motion, this change is always such, that the quantity of action (or the product of the mass by the space and the velocity) employed by nature to produce it, is the least possible. From this principle Maupertuis deduced the laws of the reflection and refraction of light, and those of the collision of bodies*. He afterwards extended its application to the laws of motion, and made the principle so general as to comprehend the laws of equilibrium, the uniform motion of the centre of gravity in the percussion of bodies, and the conservation of active forces. This celebrated principle was attacked by Koenig, professor of mathematics at the Hague, in the Leipsic acts for 1751, who not only attempted to shew its falsity, but asserted that Leibnitz had first described it in 1707 in a letter to Herman. The paper of Koenig gave rise to a long and violent dispute about the accuracy of the principle, and the authenticity of the letter of Leibnitz. The academy of Berlin interfered in behalf of their president, and gave importance to a controversy which was too personal to merit the attention which it received.

* *Mem. Acad. Paris* 1744, and *Mem. Acad. Berlin* 1746.

Euler and Lagrange generalise the principle of Maupertuis.

25. In his *Traité des Isoperimetries*, printed at Lausanne in 1744, Euler extended the principle of least action, and shewed, "that in the trajectories described by means of central forces, the integral of the velocity, multiplied by the element of the curve, is either a *maximum* or a *minimum*." This remarkable property, which Euler recognised only in the case of insulated bodies, was generalised by Lagrange into this new principle, "that the sum of the products of the masses by the integrals of the velocities, multiplied by the elements of the spaces described, is always a maximum or a minimum." In the Memoirs of Turin, Lagrange has employed this principle to resolve several difficult problems in dynamics; and he has shewn†, that when it is combined with the conservation of active forces, and developed according to the rules of his method of variations, it furnishes directly all the equations necessary for the solution of each problem, and gives rise to a simple and general method of treating the various problems concerning the motion of bodies.

† *Mecanique Analytique*, p. 189, 1788.

Labours of Segner, 1765.

26. An important discovery in rotatory motion, was at this time made by Professor Segner. In a paper, entitled *Specimen Theoriæ Turbinum*, he demonstrated, that if a body of any form or magnitude, after it has received rotatory motions in all directions, be left entirely to itself, it will always have three principal axes of rotation; or, in other words, all the rotatory motions with which it is affected, may be reduced to three, which are performed round three axes, perpendicular to each, passing through the centre of gravity of the revolving body, and preserving the same position in absolute space, while the centre of gravity is either at rest or moving uniformly in a straight line.

Coulomb inquires into the force of torsion,

27. The force of torsion began at this time to be investigated by Coulomb, who published two ingenious papers on the subject, in the Memoirs of the French Academy. He has successfully employed this principle in several physical researches, but particularly in determining the law of magnetic action, and in finding the laws of the resistance of fluids when the motions are extremely slow*. It was by means of an elegant experiment on the principle of torsion that Mr Cavendish determined the mutual attraction of two masses of lead, and thence deduced the mean density of the earth.—We are also indebted to Coulomb for a complete set of experiments on the nature and effects of friction. By employing large bodies and ponderous weights, and conducting his experiments on a large scale, he has corrected errors which necessarily arose from the limited experiments of preceding writers; he has brought to light many new and interesting facts, and confirmed others which had hitherto been partially established. The most curious result of these experiments is the effect of time in increasing the friction between two surfaces. In some cases the friction reaches its maximum after the rubbing surfaces have remained in contact for one minute; and in other cases five or six days were necessary before this effect was produced. The increase of friction, which is generated by prolonging the time of contact, is so great, that a body, weighing 1650 pounds, was moved with a force of 64 pounds when first laid upon the corresponding surface. After remaining in contact for the space of three seconds, 100 pounds were necessary to put it in motion; and when the time was prolonged to six days, it could scarcely be moved with a power of 622 pounds†.

* *Memoirs de l Institut. Nat.* tom. iii. p. 246.

and into the subject of friction.

† *Memoires Presentees* tom. ix.

Works on mechanics.

28. One of the most important treatises on the science of motion is the Mechanics of the celebrated Euler, published in 1736. It contains the whole theory of rectilineal and curvilineal motion in an insulated body, affected by any accelerating forces, either in vacuo or in a resisting medium. He uniformly uses the analytical method, and has employed the principle of the *vis inertiæ*, and that of compound motion, for putting his problems into equations. By the *vis inertiæ*, motion is at every moment of time rectilineal and uniform; and by the principle of compound motion, a body, exposed to the action of any number of forces, tending to alter the quantity and the direction of its motion, will move in such a direction as to reach the very point at which it would have arrived, had it obeyed successively each of the forces which act upon it.—In the *Mecanique Analytique* of Lagrange, published in 1788, all the mechanical problems are reduced to general formulæ, which, being developed, furnish us with the equations that are necessary for the solution of each problem; and the different principles which

Euler's mechanics.

Lagrange's Mecanique Analytique.

Theory. which have been discovered for facilitating the solutions of mechanical questions, are brought under one point of view, and their connection and dependence clearly pointed out. The *Architecture Hydraulique*, by M. Prony, published in 1790, and the *Mecanique Philosophique*, of the same author, published in 1799, contain all the late improvements in mechanics, and a complete view both of the theory and application of that science. The first of these works is intended chiefly for the use of the engineer, though an extensive acquaintance with the higher geometry is necessary for perusing it with advantage. His *Mecanique Philosophique* is a profound work, in which, without the aid of a single diagram, he gives all the formulæ, and the various theorems and problems which belong to the sciences of mechanics and hydrodynamics. Every alternate page contains a methodical table of the results obtained in the preceding page, the description of the symbols, and the theorems, problems, and formulæ which may have been obtained. The *Traité de Mecanique Elementaire*, by M. Franceur, published in 1802 in one volume octavo, is an excellent abridgement of the works of Prony, and is intended as an introduction to the *Mecanique Philosophique* of that author, to the *Mecanique Analytique* of Lagrange, and to the *Mecanique Celeste* of Laplace.—None of these works have been translated into English; but their place is well supplied by a *Treatise on Mechanics Theoretical, Practical*, and *Descriptive*, by Olinthus Gregory, A M. published in 1806, and containing a complete view of the latest improvements, both in the theory and practice of mechanics.

Prony's Architecture Hydraulique and Mecanique Philosophique.

PART I. THEORY OF MECHANICS.

Objects of theoretical mechanics.

29. THE theory of mechanics properly comprehends, 1. Dynamics. 2. The motion of projectiles. 3. The theory of simple machines, or the mechanical powers. 4. The theory of compound machines, and their maximum effects. 5. The doctrine of the centre of gravity. 6. The centre of oscillation, gyration, &c. 7. The collision of bodies. 8. The theory of rotation. 9. The theory of torsion. 10. The strength of materials; and, 11. The equilibrium of arches, domes.—The subjects of DYNAMICS, PROJECTILES, ROTATION, and STRENGTH of MATERIALS, having been already ably treated by Dr Robison, under their respective heads, we shall now direct the attention of the reader to the other branches of theoretical mechanics.

CHAP. I. *On Simple Machines*, or the *Mechanical Powers.*

Division of machines into simple and compound.

30. THE simple machines have been generally reckoned six in number. 1. The lever; 2. The wheel and axle, or *axis in peritrochio*; 3. The pulley; 4. The inclined plane; 5. The wedge; and, 6. The screw: to which some writers on mechanics have added the *balance*, and others the *rope-machine*. It is evident, however, that all these machines may be reduced to three, the *lever*, the *inclined plane*, and the *rope-machine*. The *pulley*, and the *wheel* and *axle*, are obviously composed of an assemblage of levers; the *balance* is a lever with equal arms; the *wedge* is composed of two inclined planes, with their bases in contact; and the *screw* is either a wedge or an inclined plane, wrapped round a cylinder.—Under the head of simple machines, therefore, we cannot, in strict propriety, include any of the mechanical powers, excepting the lever, the inclined plane, and the rope-machine.

DEFINITIONS.

Definitions.

31. DEF. 1. When two forces act against each other by the intervention of a machine, the one force is called the *power*, and the other the *weight*. The *weight* is the resistance to be overcome, or the effect to be produced. The *power* is the force, whether animate or inanimate, which is employed to overcome that resistance, or to produce the required effect.

32. DEF. 2. The power and weight are said to balance each other, or to be in equilibrio, when the effort of the one to produce motion in one direction, is equal to the effort of the other to produce motion in the opposite direction;—or when the weight opposes that degree of resistance which is precisely required to destroy the action of the power.

SECT. I. *On the Lever.*

Levers divided into three kinds.

33. DEFINITIONS.. A *lever* is an inflexible bar or rod moving freely round a point, called its *fulcrum* or *centre of motion.*

Levers have been generally divided into *three* kinds. In levers of the first kind the fulcrum is situated between the power and the weight, as in steelyards, scissars, pincers, &c. Levers of the second kind have the weight between the power and the fulcrum, as in cutting knives fastened at the point of the blade, and in the oars of a boat where the water is regarded as the fulcrum. In levers of the third kind, the power is between the weight and the fulcrum, as in tongs, sheers for sheep, &c. The bones of animals are generally considered as levers of the third kind, for the muscles, by the contraction of which the power or moving force is generated, are fixed much nearer to the joints or centres of motion than the centre of gravity of the weight to be raised. On this subject, see Paley's Natural Theology, chap. 7. & 8. and *Borelli de Motu Animalium*.

AXIOMS.

Axioms.

34. AXIOM 1. *Equal weights acting at the extremities of equal arms of a straight lever, and having the lines of the direction in which they act at equal angles to these arms, will exert the same effort to turn the lever round its fulcrum.* This axiom has been generally restricted to the particular case when the weights act perpendicularly to the arms of the lever; but no reason can be assigned for such limitation. The truth in the axiom is as self-evident when the angles formed by the arms of the lever and the direction of the forces are 80°, as when they are 90°, for in each case the two weights exert

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exert their influence upon the lever in precisely the same circumstances.

35. Axiom 2. *If two equal weights are placed at the extremities of a lever supported by two fulcra; and if these fulcra are at equal distances from the weights, or the extremities of the lever; the pressure upon the fulcra will be equal to the sum of the weights, and the pressure upon each fulcrum will be equal to one of the weights.* The lever being supposed devoid of weight, it is obvious, that as each fulcrum is similarly situated with respect to both the weights, the pressure upon each must be equal; and as the fulcra support both the equal weights, the pressure upon each must be equal to one of the weights.

Proposition I.

36. If two weights or forces acting at equal angles upon a straight lever, devoid of weight, are in equilibrio, they are reciprocally proportional to their distances from the fulcrum.

37. Case 1. When the weights act on contrary sides of the fulcrum.

Plate CCCXVI. fig. 1. Let AB be a lever devoid of weight, and let it be supported on the two fulcra, fF, situated in such a manner that $Af = f\mathrm{F} = \mathrm{FB}$. Then if two equal weights C, D of one pound each are suspended at the extremities A, B, so as to act in the directions AC, BD, making the angles CAB, DBA equal, these weights will be in equilibrio, for since $Af = \mathrm{FB}$ (Axiom 1.) the effort of the weight D to turn the lever round the fulcrum F, will be equal to the effort of the weight C to turn it round the fulcrum f. Now (Axiom 2.) the pressure upon the fulcrum f is equal to one pound, therefore if that fulcrum be removed, and a weight E of one pound be made to act upward at the point F, the weights C and D will continue in equilibrio. Then it is obvious that since $\mathrm{FB} = \mathrm{F}f$, the weight E of one pound acting upwards at the point f, so that the angle $\mathrm{D}f\mathrm{F} = \mathrm{DBA}$, will have the same effect as an equal weight acting downwards at B. By removing the weight E, therefore, and suspending its equal C at the extremity B, the equilibrium will still be preserved. But the weights D, C, suspended at B, are equal to two pounds, and the weight C is only one pound; and as FA is double of FB, it follows that a weight of two pounds, placed at the end of one arm of a lever, will be in equilibrio with a weight of one pound placed at twice the distance of the former from the fulcrum. But $2 : 1 = 2\,\mathrm{FB}$ or $\mathrm{AF} : \mathrm{FB}$, that is, when the distances are as 2 to 1, an equilibrium takes place if the weights are reciprocally proportional to these distances.

38. Case 2. When weights act on the same side of the fulcrum.

Fig. 2. Let AB be a lever in equilibrio upon the fulcrum F, and let FA be equal to FB, consequently (Case 1.) we must have $\mathrm{C} = \mathrm{D} = 1$ pound. Now as the fulcrum F supports a weight equal to $\mathrm{C} + \mathrm{D} = 2$ pounds, the equilibrium will continue if a weight E of two pounds is made to act upwards at the point F, for in this case it supplies the place of the fulcrum. It is obvious also that a fulcrum placed at A or B will supply the place of the weights at these parts without affecting the equilibrium. Let, therefore, the weight D be removed, and let the extremity B rest upon a fulcrum; then since the lever is in equilibrio, we have a weight $\mathrm{E} = \mathrm{C} + \mathrm{D} = 2$ pounds acting at F, and balancing a weight C of one pound acting at A. But $2 : 1 = \mathrm{AB} : \mathrm{FB}$, consequently when there is an equilibrium between two weights C, D acting at the distances 2 and 1 from the fulcrum, and on the same side of the fulcrum, the weights are reciprocally proportional to these distances.

39. Again, let AB be the same lever supported by the fulcra f, F, and let $\mathrm{A}f = \mathrm{FB}$ and $f\mathrm{F} = 2\mathrm{FB}$. Then if two weights C, D of one pound each be suspended at the extremities A, B, they will be in equilibrio as before. But since the fulcrum f supports a pressure of one pound (Axiom 2.), the equilibrium will still continue when that fulcrum is removed and a weight of one pound made to act in a contrary direction f P at the point f, so that the angle $\mathrm{P}f\mathrm{F}$ may be equal to DBA. Now, (Axiom 1.) a weight E of one pound acting upward at f will be in equilibrio with a weight E′ of one pound acting downwards at f'; $\mathrm{F}f$ being equal to $\mathrm{F}f'$, and therefore by removing E from the point f and substituting E at the point f', an equilibrium will still obtain. But since $\mathrm{F}f' = 2\mathrm{FB}$ a weight of one pound suspended from f will have the same influence in turning the lever round F as a weight of two pounds suspended at B (Case 2.). Let us remove, therefore, the weight E′ from f', and substitute a weight $\mathrm{G} = 2\mathrm{E}'$, so as to act at B. Then since the equilibrium is not destroyed, we have a weight C of one pound acting at the distance FA, and the weights $\mathrm{D} + \mathrm{G} = 3$ pounds acting at the distance FB. But $\mathrm{FA} = 3\mathrm{FB}$ and $\mathrm{D} + \mathrm{G} = 3\mathrm{C}$, consequently $\mathrm{C} : \mathrm{D} + \mathrm{G} = \mathrm{FB} : \mathrm{FA}$: That is, when the distances from the fulcrum are as 3 to 1, and when an equilibrium exists, the weights are reciprocally proportional to these distances. Fig. 3.

40. By making FA in fig. 2. equal to 2FB it may be shewn, as in Case 2. that the weights are reciprocally proportional to their distances from the fulcrum, when they act on the same side of the fulcrum, and when the distances are as 3 to 1. Fig. 2.

41. In the same way the demonstration may be extended to any commensurable proportion of the arms, by making EA to FB in that proportion, and keeping fA always equal to FB. Hence we may conclude in general, that when two weights acting at equal angles upon a straight lever devoid of weight, are in equilibrio, they are reciprocally proportional to their distances from the centre of motion. Q. E. D. Fig. 3.

42. Cor. 1. If two weights acting at equal angles upon the arms of a straight lever devoid of weight are reciprocally proportional to their distances from the fulcrum, they will be in equilibrio. Corollari

For if an equilibrium does not take place, the proportion of the weights must be altered to procure an equilibrium, and then, contrary to the proposition, the weights would balance each other when they are not reciprocally proportional to their distances from the fulcrum.

43. Cor 2. If a weight W be supported by a horizontal lever resting on the fulcra A, B, the pressure upon A is to the pressure upon B in the inverse ratio of their distances from the point where the weight is suspended, that is, as BF to FA. Fig. 4.

For if we suppose B to be the fulcrum, and if removing the

Theory.

the fulcrum A, we support the extremity A of the lever by a weight E equivalent to the weight sustained by the fulcrum A, and acting upwards over the pulley P, then the weight E or that sustained by A : W=BF : BA (Prop. 1.); and if we conceive A to be the fulcrum, and support the extremity B by a weight F equal to that which was supported by the fulcrum B, we shall have the weight F or the weight sustained by B : W=FB : FA. Hence *ex æquo* the weight sustained by A is to the weight sustained by B as BF is to FA.

Fig. 5.

44. Cor. 3. We may now call the two weights P and W, the power and the weight, as in fig. 5, and since P : W=FB : FA, we have (Geometry, Sect. iv. Theor. 8.) $P\times FA=W\times FB$, when an equilibrium takes place,

consequently $P=\dfrac{W\times FB}{FA}$; $W=\dfrac{P\times FA}{FB}$

$$FA=\frac{W\times FB}{P}$$

$$FB=\frac{P\times FA}{W}.$$

45. Cor. 4. We have already seen (Axiom 2.) that when the power and the weight are on contrary sides of the fulcrum, the pressure upon the fulcrum is equal to $P+W$ or the sum of the weights; but it is obvious that when they act on the same side of the fulcrum, the pressure which it supports will be $P-W$, or the difference of their weights.

46. Cor. 5. If a weight P be shifted along the arm of a lever AD, the weight W, which it is capable of balancing at A, will be proportional to FA.

When the weights are in equilibrio (Cor. 3.) W : P=FA : FB, or by alternation W : FA=P : FB, and if w be another value of W and fa another value of FA, we shall also have w : P=fa : FB or w : fa= P : FB, consequently (Euclid, Book v. Prop. xi. and xvi.) W : w=FA : fa, that is, W varies as FA.

Fig. 6.

Cor. 6. It is obvious that the truths in the preceding proposition and corollaries, also hold when the lever has the form represented in fig. 6. only the straight lines AF, FB are in that case the length of the arm.

Description of the steelyard or statera.

47. Cor. 7. Since by the last corollary FA : fa= W : w, it follows that in the *Roman statera* or *steelyard*, which is merely a lever with a long and short arm, having a weight moveable upon the long one, the distances at which the constant weight must be hung are as the weights suspended from the shorter arm. The steelyard is represented in fig. 7. where AB is the lever with unequal arms AF, FB, and F the centre of motion. The body W, whose weight is to be found, is suspended at the extremity B of the lever, and the constant weight P is moved along the divided arm FB till an equilibrium takes place. As soon as this happens, the number placed at the point of suspension D, indicates the weight of the body. If the lever is devoid of weight, it is obvious that the scale EB will be a scale of equal parts of which EB is the unit, and that the weight of the body W will be always equal to the constant weight P multiplied by the number of divisions between P and F. Thus if the equilibrium takes place when P is pulled out to the 12 division, we shall have W=12 P, and if P=1 pound, W=12 pounds. But when the gravity

Fig. 7.

of the lever is considered, which must be done in the real steelyard, its arms are generally of unequal weight, and therefore the divisions of the scale must be ascertained by experiment. In order to do this, remove the weight P, and find the point C, at which a weight P′ equal to P being suspended, will keep the unequal arms in equilibrio, C will then be the point at which the equal divisions must commence. For when W and P are placed upon the steelyard and are in equilibrio, W balances P along with a weight which, placed at D, would support P placed at C: Therefore $W\times BF=P\times DF+P\times CF$; but $P\times DF+P\times CF=P\times DC$, consequently $W\times BF=P\times DC$, and (Geometry, Sect. iv. Theor. 8.) W : DC=P : BF. By taking different values of the variable quantities W and DC as w and dc, we shall have w : dc=P : BF, consequently (Euclid, B. V. Prop. xi. and xvi.) W : w=DC : dc, that is, the weight of W varies as DC, and therefore the divisions must commence at C. If the arm BF had been heavier than FA, which, however, can scarcely happen in practice, the point C would have been on the other side of F. In constructing steelyards, it might be advisable to make the unequal arms balance each other by placing a weight M at the extremity of the lighter arm, in which case the scale will begin at F. In the Danish and Swedish steelyard the body to be weighed and the constant weight are fixed at the extremities of the steelyard, but the point of suspension or centre of motion F moves along the lever till the equilibrium takes place. The point F then indicates the weight of the body required. —There are some steelyards in which the constant weight is fixed to the shorter arm, while the body to be weighed moves upon the longer arm. The method of dividing this and the preceding steelyard may be seen in De la Hire's *Traité de Mecanique*, Prop. 36, 37, 38.

Danish and Swedish steelyard.

Prop. II.

48. To find the condition of equilibrium on a straight lever when its gravity is taken into the account.

Fig. 8.

49. Let us suppose the lever to be of uniform thickness and density, as AB, fig. 7. and let it be suspended by the points c, d to another lever $a\,b$, considered as without weight, so that $a\,c=c\,f=f\,d=d\,b$. Then if f be the centre of motion or point of suspension, the cylinder A B will be in equilibrio; for the weight AB may be regarded as composed of a number of pairs of equal weights, equally distant from the centre of motion. For the same reason, if we conceive the cylinder to be cut through at F the equilibrium will continue, c, d being now the points at which the weights AF, FB act, and their distances $c\,f$, $d\,f$ from the centre of motion being equal. Consequently the arms AF, FB have the same energy in turning the lever round f as if weights equal to AF, FB were suspended at the distance of their middle points c, d from the fulcrum.

Fig. 5.

Let P therefore, in fig. 5. be the power, W the weight, m the weight of the arm AF, and n the weight of FB. Then when there is an equilibrium we shall have (Prop. I. Cor. 3.) $P\times AF+m\times\frac{1}{2}AF=W\times FB+n\times\frac{1}{2}FB$; and since the weight m, acting at half the distance AF is the same as half the weight m acting at the

Theory. the whole distance AF, we may substitute $\frac{1}{2}m \times AF$ instead of $m \times \frac{1}{2}AF$, and the equation becomes $\overline{P+\frac{1}{2}m} \times AF = \overline{W+\frac{1}{2}n} \times FB$. Hence

$$P = \frac{\overline{W+\frac{1}{2}n} \times FB}{AF} - \frac{1}{2}m$$

$$W = \frac{\overline{P+\frac{1}{2}n} \times AF}{FB} - \frac{1}{2}n$$

$$m = \frac{\overline{W=\frac{1}{2}n} \times 2FB}{AF} - 2P$$

$$n = \frac{\overline{P+\frac{1}{2}n} \times 2FB}{FB} - 2W$$

$$AF = \frac{\overline{W+\frac{1}{2}n} \times FB}{P+\frac{1}{2}m}$$

$$FB = \frac{\overline{P+\frac{1}{2}m} \times AF}{W+\frac{1}{2}m}.$$

50. Cor. If the arms of the lever are not of uniform density and thickness, instead of the distance of their middle points, we must take the distance of their centre of gravity from the fulcrum.

Prop. III.

51. If two forces acting in any direction, and in the same plane, upon a lever of any form, are in equilibrio, they will be reciprocally proportional to the perpendiculars let fall from the fulcrum upon the directions in which they act.

Plate CCCXVII. Fig. 1. & 2. 52. Let AFB be a lever of any form, F its fulcrum, A, B the points to which the forces, or the power P and weight W, are applied, and AE, BK the directions in which these forces act. Make AE to PK as P is to W, and they will therefore represent the forces applied at A and B. Draw AC perpendicular to AF and EC parallel to it, and complete the parallelogram ADEC. In the same way form the parallelogram BGKH. Produce EA and KB towards m and n if necessary, and let fall F m, F n perpendicular to AE, BK produced. Then P shall be to W as Fn is to Fm. By the resolution of forces (Dynamics, § 140.) the force AE is equivalent to forces represented by AD and AC, and acting in these directions. But as AD acts in the direction of the arm AF, it can have no influence in turning the lever round F, and therefore AC represents the portion of the force AD which contributes to produce an angular motion round F. In the same way it may be shewn that BG is the part of the force BK which tends to move the lever round F. Now suppose AF produced to B, FB being made equal to FB and B′G′=BG. Then by Prop. I. AC : B′G′ =FB′ : FA; but by Axiom 1. the effort of BG to turn the lever round F is equal to the effort of the equal force B′G′ to turn the lever round F; therefore AC : BG=FB : FA and AC×FA=BG×FB. Now the triangles ACE, AE m are similar, because the angles at F and M are both right, and on account of the parallels DF, AC, MAC=ADF; therefore AC : AE=F m : FA, and AC×FA=AE×F m. For the same reason in the similar triangles BGK, BF n we have BG : BK=F n : FB, and BK×Fn=BG×FB. Hence AE×Fm=BK×Fn, and AE : BK or P : W =F n : Fm. Q. E. D. Theory.

53. Cor. 1. The forces P and W are reciprocally Corollaries. proportional to the sines of the angles which their di- Fig. 1 & 2. rections make with the arms of the lever, for F m is evidently the sine of the angle FA m, and F n the sine of the angle FB n, FA, FB being made the radii;—therefore P : W=Sin. FB n : Sin. FA m, or P : W $=\frac{1}{\text{Sin. FA}\,m} : \frac{1}{\text{Sin. FB}\,n}$. Since FA : F m=Rad. : Sin. FAm, we have F$m=\frac{\text{FA}\times\text{Sin. FA}m}{\text{Rad.}}$; and since FB : F$n$=Rad. : Sin. FB$n$, we have F$m=\frac{\text{FB}\times\text{Sin. FB}n}{\text{Rad.}}$, but in the case of an equilibrium P : W=Fn : Fm, consequently P : W$=\frac{\text{FB}\times\text{Sin. FB}\,n}{\text{Rad.}} : \frac{\text{FA}\times\text{Sin. FA}\,m}{\text{Rad.}}$; and since magnitudes have the same ratio as their equimultiples, P : W=EB×Sin. EB n : FA×Sin. FAm.

54. Cor. 2. The energies of the forces P, W to turn the lever round the fulcrum F is the same at whatever point in the directions mE, nK they are applied, for the perpendiculars to which these energies are proportional remain the same.—The truth of this corollary has been assumed as an axiom by some writers on mechanics, who have very readily deduced from it the preceding proposition. But it is very obvious that the truth assumed as self-evident is nearly equivalent to the truth which it is employed to prove. Those who have adopted this mode of demonstration illustrate their axiom by the case of a solid body that is either pushed in one direction with a straight rod, or drawn by a cord; in both of which cases it is manifest that the effect of the force employed is the same, at whatever part of the rod or string it is applied: But these cases are completely different from that of a body moving round a fixed centre.

55. Cor. 3. If AE and BK the directions in which the forces P, W are exerted be produced till they meet at L; and if from the fulcrum E thel ine FS be drawn parallel to the direction AL of one force till it meets BL, the direction of the other; then LS, SF will represent the two forces. For as the sides of any triangle are as the sines of the opposite angles LS : SF=sin. LFS : sin. FLS; but on account of the parallels FS, AL the angle LFS=FLA, and FL being radius F m is the sine of FLA or LFS, and F n the sine of FLS, therefore by substitution LS : SF=F m : Fn, that is as the force W : P.

56. Cor. 4. If several forces act upon a lever, and keep it in equilibrio, the sum of the products of the forces and the perpendiculars from the fulcrum to the direction of the different forces on one side is equal to the sum of the products on the other. For since the energy of each force to turn the lever is equal to the product of the force and the perpendicular from the fulcrum on the line of its direction; and since in the case of an equilibrium, the energy of all the forces on one side of the fulcrum must be equal to the energy of all the forces on the other side, the products proportional to their energies must also be equal.

57. Cor. 5. If two forces act in a parallel direction upon an angular lever whose fulcrum is its angular point,

Theory. point, these forces will be in equilibrio when a line drawn from the fulcrum upon the line which joins the two points where the forces are applied, and parallel to the direction of the forces, cuts it in such a manner that the two parts are reciprocally proportional to the forces applied.

Fig. 3. Let AFB be the angular lever, whose fulcrum is F, and let the forces P, W be applied at A and B in the parallel directions P m, W n; then if the line FD, parallel to Pm or Wn, cut AB in such a manner that DB : DA=P : W, the forces will be in equilibrio. Draw Fm perpendicular to Pm, and produce it to n; then since Am, Bn are parallel, mn will also be perpendicular to Bn, and by the proposition (Art. 51.) Fn : Fm=P : W. Now, if through F, there be drawn $m'n'$ parallel to AB, the triangles Fmm', Fnn' will be similar, and we shall have Fn : Fm=Fn' : Fm', but on account of the parallels AB, $m'n'$; Fn' : Fm' =DB : DA, therefore DB : DA=P : W.

Fig. 4. 58. Cor. 6. Let CB be a body moveable round its centre of gravity F, and let two forces P, W act upon it at the points A, B in the plane AFB, in the directions AP, BW; then since this body may be regarded as a lever whose fulcrum is F, the forces will be in equilibrio when P : W=Fn : Fm the perpendiculars on the directions in which the forces act.

Fig. 5. 59. Cor. 7. If AB be an inflexible rod moveable round F as a fulcrum, and acted upon by two forces P, W in the directions Am, An, these forces will be in equilibrio when they are to one another as the perpendiculars Fn, Fm.—For by cor. 2. the forces may be considered as applied at m and n, and mFn may be regarded as the lever; but by the proposition (Art. 51.) P : W=Fn : Fm; Fm, Fn being perpendiculars upon Am, An.

Fig. 6. 60. Cor. 8. Let DE be a heavy wheel, and FG an obstacle over which it is to be moved, by a force P, acting in the direction AH. Join AF, and draw Fm, Fn perpendicular to CA and AH. The weight of the wheel is evidently the weight to be raised, and may be represented by W acting at the point A in the vertical direction AC. We may now consider AF as a lever whose fulcrum is F, and by cor. 7. there will be an equilibrium when P : W=Fn : Fm. Since Fm represents the mechanical energy of the power P to turn the wheel round F, it is obvious that when FG is equal to the radius of the wheel, the weight P, however great, has no power to move it over the obstacle; for when FG=AC, Fm=o, and Fm×P=o.

Fig. 7. 61. Cor. 9. If a man be placed in a pair of scales hung at the extremities of a lever, and is in equilibrio with a weight in the opposite scale, then if he presses against any point in the lever, except that point from which the scale is suspended, the equilibrium will be destroyed. Let CB be the lever in equilibrio, F its fulcrum, and let the scales be suspended from A and B, AP being the scale in which the man is placed. Then if he presses with his hand or with a rod against D, a point nearer the centre than A, the scale will take the position AP′, and the same effect will be produced as if AD were a solid mass acting upon the lever in the direction of gravity. Consequently if P′p be drawn perpendicular from the point P′ to FC, Fp will be the lever with which the man in the scale tends to turn the lever round the fulcrum; and as Fp is greater than FA, the man will preponderate. In the same way it may be shown, that if the man in the scale AP presses upwards against a point C, more remote from the fulcrum than A, he will diminish his relative weight, and the scale W will preponderate, for in this case the scale assumes the position AP″, and Fp' becomes the lever by which it acts. Theory.

62. Cor. 10. If a weight W be supported by an inclined lever resting on the fulcra A, B, the pressure upon A is to that upon B inversely, as Af is to fb, the sections of a horizontal line by the vertical direction of the weight W. Fig. 8.

Remove the fulcrum A, and support the extremity A by a weight P, equal to the pressure upon A; then B being the centre of motion, and mn being drawn through F perpendicular to the direction of the forces Am, Ef, and consequently parallel to Ab, we have (Art. 51.) P : W=Fn : Fm=fb : fA, that is, the pressure upon A is to the pressure upon B inversely as Af is to fb.

Scholium.

63. Various attempts have been made by different writers on mechanics to give a complete and satisfactory demonstration of the fundamental property of the lever. The first of these attempts was made by Archimedes, who assumes as an axiom, that if two equal bodies be placed upon a lever, they will have the same influence in giving it a rotatory motion as if they were both placed in the middle part between them. This truth, however, is far from being self-evident, and on this account Mr Vince * has completed the demonstration by making this axiom a preliminary proposition. The demonstration of Galileo † is both simple and elegant, and does not seem to have attracted much notice, though in principle it is exactly the same as that of Archimedes completed by Mr Vince. Galileo suspends a solid cylinder or prism from a lever by several threads. When the lever is hung by its centre, the whole is in equilibrio. He then supposes the cylinder to be cut into two unequal parts, which from their mode of suspension still retain their position, and then imagines each part of the cylinder to be suspended by its centre from the lever. Here then we have two unequal weights hanging at unequal distances from the centre of suspension, and it follows from the construction, that these weights are in the reciprocal ratio of their distances from that centre. Mr Vince, on the other hand, employs a cylinder balanced on a fulcrum. He supposes this cylinder divided into unequal parts, and thus concludes, from his preliminary proposition, that these unequal parts have the same effect in turning the lever as if the weight of these parts was placed in their centres; which is done by Galileo by suspending them from their centres. From this the fundamental property of the lever is easily deduced.—The next demonstration was given by Huygens, who assumes as an axiom, that if any weight placed upon a lever is removed to a greater distance from the fulcrum, its effort to turn the lever will be increased. This axiom he might have demonstrated thus, and his demonstration would have been completely satisfactory, though it applies only to cases where the arms of the lever are commensurable. Let AB be a lever with equal weights C, D, supported on the fulcra f, F, so that Af= Plate CCCXVI. Fig. 1.

* *Phil. Trans.* 1794, p. 33.

† *Discursus et Demonstrationes Mathemat.* Dial. ii. p. 98.

Theory. $Af=FB$; then, as was shown in Prop. I. the weights will be in equilibrio, and each fulcrum will support a weight equal to C or D. By removing the fulcrum f, the weight C must descend, as the equilibrium is destroyed by a weight equal to C acting at f; therefore the weight C, at the distance AF, has a greater effect in turning the lever than an equal weight D placed at a less distance FB.—In Sir Isaac Newton's demonstration, it is supposed that if a given weight act in any direction, and if several radii be drawn from the fulcrum to the line of direction, the effort of that weight to turn the lever will be the same to whatever of these radii it is applied. It appears, however, from Art. 54. that this principle is far from being self-evident, and therefore the demonstration which is founded upon it cannot be admitted as satisfactory. The demonstration given by Maclaurin * is simple and convincing, and has been highly approved of by Dr T. Young and other writers on mechanics, though it extends only to any commensurable proportion of the arms. He supposes the lever AB with equal arms to be in equilibrio upon the fulcrum F, by means of the equal forces P, W, in which case the fulcrum F will evidently be pressed down with a weight equal to $2\,P=P+W$. He then substitutes, instead of the weight P, a fixed obstacle O, which will not destroy the equilibrium, and *considers the fulcrum as still loaded with a weight equal to* $P+W$. The pressure on F being therefore equal to 2 P or $P+W$, a weight E equal to 2 P, and acting upwards, is substituted in the room of that pressure, so that the equilibrium will still continue. Here then we have a lever AB of the second kind, influenced by two forces E and W acting at different distances from the fulcrum A; and since $E=2\,P=2\,W$, and $AB=2\,AF$, we have $E:W=AB:AF$, which expresses the fundamental property of the lever. Without objecting to the circumstance that this demonstration applies only to the lever of the second kind, we may be allowed to observe, that it involves an axiom which cannot be called self-evident. It is certainly manifest that when P and W are in equilibrio, the pressure upon the fulcrum is $=2\,P=P+W$; but it by no means follows that this pressure remains the same when the fixed obstacle O is substituted in the room of P. On the contrary, the axiom assumed is a result of the proposition which it is employed to prove, or rather it is the proposition itself. For if, when the extremity A bears against the obstacle O, the pressure upon F is equal to 2 W, the force W obviously produces a pressure $=2W$ at half the distance AB, which is the property to be demonstrated. —The demonstrations given by Mr Landen and Dr Hamilton, the former in his Memoirs, and the latter in his Essays †, though in a great measure satisfactory, are long and tedious. In the demonstration of Dr Hamilton, he employs the following proposition: that when a body is at rest, and acted upon by three forces, they will be to one another as the three sides of a triangle parallel to the direction in which the forces act. When the three forces act on one point of a body, the proposition is true, but it is not applicable to the case of a lever where the forces are applied to three different points, and at all events the demonstration does not hold when any two of the forces act in parallel directions. The demonstration which we have given in Prop. I. is new, and different from any that have been noticed. The truths on which it is founded are perfectly axiomatic; and the only objection to which it seems liable is, that the demonstration extends only to a commensurate proportion of the arms of the lever.—An analytical demonstration of the fundamental property of the lever was given by Foncenex in the Miscellan. Jour. tom. ii. p. 321. which was afterwards improved by D'Alembert in the Mem. de l'Acad. 1769. p. 283.

* *Account of Newton's Discoveries.*

Plate CCCXVII. Fig. 9.

† See also *Phil. Trans.* vol. xciii. p. 113.

Prop. IV.

Plate CCCXVIII. Fig. 1.

64. When several levers AB, $a\,b$, $\alpha\,\beta$, whose fulcra are F, f, φ, are so combined as to act perpendicularly upon each other, or at equal angles; and if the directions in which the power and weight are applied, be also perpendicular to the arms, or at the same angles with them as those at which the levers act upon each other, there is an equilibrium when $P:W=\overline{BF\times bf\times\beta\varphi}:\overline{AF\times af\times\alpha\varphi}$.

Let M be the force which is exerted by the first lever AB upon the second $a\,b$, and N the force which is exerted by the second lever $a\,b$ upon the third $\alpha\,\beta$, then by Prop. I.

$$P:M=BF:AF$$
$$M:N=bf:af$$
$$N:W=\beta\varphi:\alpha\varphi.$$

Consequently by composition

$$P:W=\overline{BF\times bf\times\beta\varphi}:\overline{AF\times af\times\alpha\varphi}.$$

Prop. V.

65. To explain the new property of the lever discovered by M. Æpinus, and extended by Van Swinden.

Let AFB be any lever whose fulcrum is F, and to whose extremities A, B are applied the forces P, W in the directions AY, BO. Join AB, and produce it on both sides towards E and I. Produce also the lines YA, VB till they meet in H, and from H, through the fulcrum F, draw HFf, dividing AB into two parts Af, Bf. Let UM be a line given in position, and let α, β represent the angles which the direction of the forces YA, VB make with that line. Let YA and VB likewise represent the intensity of the forces P, W, and let VA be resolved into AE and YF; and the force VB into BI and VI.—Then the lever cannot be in equilibrium till Fig. 2.

I. $\overline{EA\times fA}+\overline{IB\times fB}$ is a maximum.

II. Or putting φ for the angles formed by the lines AB, UT, which the lever, when in equilibrio, makes with the line UM given in position, there cannot be an equilibrium till

$$\overline{\text{Tang.}\,\varphi\times P\times Af\times\text{Cos.}\,\alpha}+\overline{\text{Tang.}\,\varphi\times W\times Bf\times\text{Cos.}\,\beta}=\overline{W\times Bf\times\text{Sin}\,\beta}-\overline{P\times Af\times\text{Sin.}\,\alpha}.$$

III. And

III. And putting a, b for the arms AF, BF, and m, n for the angles EAB, EBA, there cannot be an equilibrium unless

$$\text{Tang. } \varphi = \frac{\text{W}.\,b\,(\text{Sin. }\beta \times \text{Cos. } n - \text{Sin. } n \times \text{Cos. }\beta) - \text{P}.\,a\,(\text{Sin. }\alpha \times \text{Cos. } m - \text{Sin. } m \times \text{Cos. }\alpha.)}{\text{P}.\,a\,(\text{Cos. }\alpha \times \text{Cos. } m + \text{Sin. }\alpha \times \text{Sin. } m) + \text{W}.\,b\,(\text{Cos. }\beta \times \text{Cos. } n + \text{Sin. }\beta \times \text{Sin. } n.)}.$$

As the demonstrations of these different cases are far from being elementary, we shall only refer the reader to the memoir upon this subject given by Æpinus in the *Nov. Comment. Petropol.* tom. viii. p. 271.

Scholium.

66. This property of the lever was only considered by Æpinus in the case of a rectilineal lever with equal arms; but was extended by J. H. Van Swinden. When the lever is rectilineal and with equal arms, we have AF=FB=Af=Bf, and also $m=n=0$, so that, if the last formula is suited to these conditions, we shall have the formula of Æpinus.

Prop. VI.

67. **If a power and weight acting upon the arms of any lever be in equilibrio, and if the whole be put in motion, the velocity of the power is to the velocity of the weight as the weight is to the power.**

Fig. 3. Let AFB be any lever whose fulcrum is F, and let the power P and weight W be applied to its extremities A, B, so as to be in equilibrio. Draw F m, F n perpendicular to AD, BE the direction of the forces P, W. Then suppose an uniform angular motion to be given to the lever, so as to make it describe the small angle AFA′, the position of the lever will now be A′FB′, and the directions of the forces, P, W will be A′D′, B′E, parallel to AD, BE respectively, since the angle AEF is exceedingly small. Join AA′, BB′, and from A′ and B′ draw A′x, B′z perpendicular to AD and BE. Now it is obvious, that though the point A has moved through the space AA′ in the same time that the point B has described the space BB′, yet A x is the space described by A in the direction AD, and B z the space described by B in the direction BE. For if we suppose a plane passing through A at right angles to AD, and another through P parallel to the former plane, it is manifest that A x measures the approach of the point A to the plane passing through P; and for the same reason B z measures the approach of the point B to a plane passing through W at right angles to WB. Therefore A x, B z represent the spaces uniformly and simultaneously described by the points A, B, and may therefore be taken to denote the velocities of these points (Dynamics, § 14.); consequently the velocity of A : the velocity of B=A x : B z. Now, in the triangles A x A′, F m A, the exterior angle x AF=A m F+m F, A (Euclid, B. I. Prop. 32.) and A′AF=A m F, because AFA′ is so exceedingly small that A′A is sensibly perpendicular to AF; consequently x AA′=AE m: and as the angles at x and m are right, the triangles A x A′, A m F are similar (Geometry, Theor. XX. Sect. IV.).

Therefore, A x : AA′=F m : FA, and in the similar triangles AFA′, BFB′ AA′ : BB′=FA : FB, and in the similar triangles BB′z, BF n, BB′ : Bz=FB : F n, therefore by composition we have A x : B z=Fm : Fn. But by Proposition II. P : W=Fn : Fm, consequently Ax : Bz=W : P, that is, the velocity of the power is to the velocity of the weight as the weight is to the power. Q. E. D.

68. Cor. Since Ax : Bz=W : P we have Ax×P =Bz×W, that is, the momenta of the power and weight are equal.

Sect. II. *On the Inclined Plane.*

69. Definition. An *inclined plane* is a plane surface AB, supported at any angle ABC formed with the horizontal plane BC. The *inclination of the plane* is the angle which one line in the plane AB forms with another in the horizontal plane BC, both these lines being at right angles to the common intersection of the two planes.—The line BA is called the *length of the plane*, AC its *height*, and BC the *length of its base*. Plate CCCXVIII fig. 4.

70. In order to understand how the inclined plane acts as a mechanical power, let us suppose it necessary to elevate the weight D from C to A. If this weight is lifted by the arms of a man to the point A, he must support the whole of the load; but when it is rolled up the inclined plane, a considerable part of its weight is supported upon the plane, and therefore a much smaller force is capable of raising it to A.

Prop. I.

71. **When any weight W is kept in equilibrio upon an inclined plane by a power P, the power is to the weight as the sine of the plane's inclination is to the sine of the angle which the direction of the power makes with a line at right angles to the plane.**

Let MN be the inclined plane, NO a horizontal line, and MNO the inclination of the plane, and let the weight W be sustained upon MN by means of the power P acting in the direction AE. From the point A, the centre of gravity of the weight, draw AB perpendicular to the horizontal plane ND, and AF perpendicular to MN; produce EA till it meets the plane in C, and from the point F where the body touches the plane draw Fm at right angles to AC, and Fn at right angles to AB. Then, since the whole body may be considered as collected in the centre of gravity A, AB will be the direction in which it tends to fall, or the direction of the weight, and EA is the direction of the power; but AF is a lever whose fulcrum is F, and since it is acted upon by two forces which are in equilibrio, we shall have (Art. 59.) P : W=F n : F m, that is, as the perpendiculars drawn from the fulcrum to the direction in which the forces act. Now FA being radius, F n is the sine of the angle FAB, and F m is the sine of the angle FAC; but FAB is equal to MNO the angle of the plane's inclination, on account of the right angles at F and B and the vertical angles at D; and FAC is the angle which the direction of the power makes with a line perpendicular to the plane; therefore P : W as Fig. 5.

Theory. as the sine of the plane's inclination, is to the sine of the angle formed by the direction of the power with a line at the right angles to the plane.

72. Cor. 1. When the power acts parallel to the plane in the direction AE′, P is to W as EA to E n, that is, as radius is to the sine of the plane's inclination, or on account of the similar triangles F A n, MNO, as the length of the plane is to its height. In this case the power acts to the greatest advantage.

73. Cor. 2. When the power acts in a vertical line A ϵ, F m becomes equal to or coincides with F n, and we have P : W=F n : F n, that is, the power in this case sustains the whole weight.

74. Cor. 3. When the power acts parallel to the base of the plane in the direction A e, P : W=F n : Ff =Fn : A n.

75. Cor. 4. When the power acts in the direction AF e' perpendicular to the plane, it has no power to resist the gravity of the weight; for the perpendicular from the fulcrum F, to which its energy is proportional, vanishes.

76. Cor. 5. Since the body W acts upon the plane in a direction AF perpendicular to the plane's surface, (for its force downwards may be resolved into two, one parallel to the plane, and the other perpendicular to it), and since the reaction of the plane must also be perpendicular to its surface (Dynamics, § 149.), that is, in the direction FA, then, when the direction of the power is A e parallel to the horizon, the power, the weight, and the pressure upon the plane, will be respectively as the height, the base, and the length of the plane. The weight W is acted upon by three forces; by its own gravity in the direction A n, by the reaction of the plane in the direction AF, and by the power P in the direction AF. Therefore, since these forces are in equilibrio, and since Af is parallel to nF, and Ff to An, the three sides AF, Af, Ff, will represent the three forces (Dynamics, § 144.). But the triangle AFf is similar to AnF, that is, to MNO, for it was already shewn that the angle n AF is equal to MNO, therefore, since in the triangle AFf, AF represents the pressure on the plane, Af the weight of the body, and Ff the energy of the power, these magnitudes will also be represented in the similar triangle MNO by the sides MN, MO, NO.

Fig. 6. 77. Cor. 6. If a power P and weight W are in equilibrio upon two inclined planes, AB, AC; P : W= AB : AC. Let p be the power, which acting on the weight W in a direction parallel to the plane would keep it in equilibrio, then we have p : W=AD : AC; but since the string is equally stretched at every point, the same power p will also sustain the power P, consequently P : p=AB : AD, and by composition P : W =AB : AC.

Prop. II.

78. If a spherical body is supported upon two inclined planes, the pressures upon these planes will be inversely as the sines of their inclination, while the absolute weight of the body is represented by the sine of the angle formed by the two planes.

Fig. 7. Let AC, BC be the two inclined planes, and F the spherical body which they support. The whole of its matter being supposed to be collected in its centre of gravity F, its tendency downwards will be in the vertical line FO. The reaction of the planes upon F is evidently in the direction MF, NF perpendicular to the surface of these planes, and therefore we may consider the body F as influenced by three forces acting in the directions FC, FM, FN; but these forces are represented by the sides of the triangle ABC perpendicular to their directions, (Dynamics, § 144.), consequently the absolute weight of the body F, the pressure upon the plane AC, and the pressure upon the plane BC, are respectively as AB, AC, and BC, that is, as the sines of the angles ACD, ABC, BAC, for in every triangle the sides are as the sines of the opposite angles, or to express it in symbols, W being the absolute weight of the body, w the pressure on AC, and w' the pressure on BC,

$$W : w : w' = AB : AC : BC, \text{ or}$$
$$W : w : w' = \sin. ACB : \sin. ABC : \sin. BCA.$$

But on account of the parallels AB, DF, the angle ABC=BCF, and BAC=ACD, therefore the pressures upon the planes are inversely as the sines of their inclination, the absolute weight of the body being represented by the sine of the angle formed by the surfaces of the two planes.

Corollaries. 79. Cor. 1. Since the two sides of a triangle are greater than the third, the sum of the relative weights supported by the two planes is greater than the absolute weight of the body.

80. Cor. 2. If the inclination of each plane is 60°, then ACB must also be 60°, and the triangle ABC equilateral, consequently the pressure upon each plane is equal to the absolute weight of the body.

81. Cor. 3. When the inclination of each plane increases, the pressure which each sustains is also increased; and when their inclination diminishes till it almost vanishes, the pressure upon each plane is one half of the absolute weight of the body F.

Prop. III.

82. If a body is raised with an uniform motion along an inclined plane, the velocity of the power is to the velocity of the weight as the weight is to the power.

Fig. 8. Let the weight W be drawn uniformly up the inclined plane AB, from B to D, by a power whose direction is parallel to DH. Upon DB describe the circle BFEDN, cutting BC in E, and having produced HD to F, join FP, FB, FE, and draw DC perpendicular to BD. Now the angles BFD, BED are right (Geometry, Sect. II. Theor. 17.), and therefore, though the power moves through a space equal to BD, yet its velocity in the direction DH is measured by the space FD uniformly described; and for the same reason, though the weight W describes the space BD, yet its velocity in the direction in which it acts, that is, in a vertical direction, is evidently measured by the space DE uniformly described. Then because the triangle DBE is equal to DFE, (Geometry, Sect. II. Theor. 15.) and DBE=DCH, (Geometry, Sect. IV. Theor. 23.) and FDE=DHC, (Geometry, Sect. I. Theor. 21.)

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21.) the triangles DFE, DHC are similar, and (GEOMETRY, Sect. IV. Theor. 20.) DF : DE=DH : HC. But DH : HC=sin. DCH . sin. HDC, that is, (art. 71.) DF : DE, or the velocity of the power to the velocity of the weight, as W : P. Q. E. D.

SCHOLIUM.

83. The inclined plane, when combined with other machinery, is often of great use in the elevation of weights. It has been the opinion of some writers, that the huge masses of stone which are found at great altitudes in the splendid remains of Egyptian architecture, were raised upon inclined planes of earth, with the aid of other mechanical powers. This supposition, however, is not probable, as the immense blocks of granite which compose the pyramids of Egypt could not possibly have been raised into their present situation by any combination of the mechanical powers with which we are acquainted.—The inclined plane has been very advantageously employed in the duke of Bridgewater's canal. After this canal has extended 40 miles on the same level, it is joined to a subterraneous navigation about 12 miles long by means of an inclined plane, and this subterraneous portion is again connected by an inclined plane with another subterraneous portion about 106 feet above it. This inclined plane is a stratum of stone which slopes one foot in four, and is about 453 feet long. The boats are conveyed from one portion of the canal to another by means of a windlass, so that a loaded boat descending along the plane turns the axis of the windlass, and raises an empty boat.—A pair of stairs, and a road that is not level, may be regarded as inclined planes; and hence it is a matter of great importance, in carrying a road to the top of a hill, to choose such a line that the declivity may be the least possible. The additional length, which, in order to effect this purpose, must sometimes be given to the line of road, is a trifling inconvenience, when compared with the advantages of a gentle declivity.

SECT. III. *On the Rope Machine.*

84. DEFINITION. When a body suspended by two more ropes, is sustained by powers which act by the assistance of these ropes, this assemblage of ropes is called a *rope machine.*

PROP. I.

85. If a weight is an equilibrium with two powers acting on a rope machine, these powers are inversely as the sines of the angles which the ropes form with the direction of the weight.

Fig. 9.

Let the weight W be suspended by the point B, where the ropes AB, BC are joined, and let the powers P, p acting at the other extremities of the ropes which pass over the pulleys A, C, keep this weight in equilibrio, we shall have P : p=sin. CBD : sin. ABD. Produce WB to F, and let BD represent the force exerted by W; then by drawing DE parallel to AB, the sides of the triangle BDE will represent the three forces by which the point B is solicited (DYNAMICS, § 144.), for AB, CB are the directions of the forces P and p. We have therefore P : p=DE : BE; but DE : BE=sin. DBE : sin. BDE, and on account of the parallels DE, AB, the angle BDE=ABD, consequently P : p=sin. DBE : sin. BDE.

Theory.

86. COR. 1. When the line joining the pulleys is horizontal, as AC, then P : p=FC : FA, for FC and FA are evidently the sines of the angles DBE, BDE.

87. COR. 2. Any of the powers is to the weight, as the sine of the angle which the other makes with the direction of the weight, is to the sine of the angles which the powers make with one another. For since DB represents the weight, and BE the power P, we have BE : BD=sin. BDE : sin. BED; but on account of the parallels DE, AB, the angle DEB=ABC, the angle made by the direction of the powers, consequently BE : BD, that is, p : W=sin. ABF : sin. ABC. In the same way it may be shown that P : W=sin. CBF : sin. ABC. Hence we have P+p : W=$\overline{\text{sin. CBF+sin. ABF}}$: sin. ABC, that is the sum of the powers is to the weight, as the sum of the sines of the angles which the powers make with the direction of the weight is to the sine of the angle which the powers make with one another.

88. COR. 3. The two powers P, p, are also directly proportional to the cosecants of the angles formed by the direction of the powers with the direction of the weight. For since P : p=sin. DBE : sin. BDE, and by the principles of trigonometry, sin. DBE : sin. DBE =cosec. BDE : cosec. DBE, we have P : p=cosec. ABF : cosec. CBF. It is also obvious that P : p as the secants of the angles which these powers form with the horizon, since the angles which they make with the horizon are the complements of the angles which they form with the direction of the weight, and the cosecant of any angle is just the secant of its complement, therefore P : p=sec. BAF : sec. BCF.

CHAP. II. *On Compound Machines.*

89. DEFINITION. Compound machines are those which are composed of two or more simple machines, either of the same or of different kinds. The number of compound machines is unlimited, but those which properly belong to this chapter, are, 1. The wheel and axle; 2. The pulley; 3. The wedge; 4. The screw; and, 5. The balance.

SECT. I. *On the Wheel and Axle.*

90. The *wheel and axle*, or the axis in peritrochio, Fig. 10. is represented in fig. 9. and consists of a wheel AB, and cylinder CD, having the same axis, and moving upon pivots E, F, placed at the extremity of the cylinder. The power P is most commonly applied to the circumference of the wheel, and acts in the direction of the tangent, while the weight W is elevated by a rope which coils round the cylinder CD in a plane perpendicular to its axis.—In this machine a winch or handle EH is sometimes substituted instead of the wheel, and sometimes the power is applied to the levers S, S fixed in the periphery of the wheel; but in all these forms the principle of the machine remains unaltered.—That the wheel and axle is an assemblage of levers will be obvious, by considering that the very same effect would be produced if a number of levers were to radiate

Theory. diate from the centre C, and if a rope carrying the power P were to pass over their extremities, and extricate itself from the descending levers when they come into a horizontal position.

91. Axiom. The effect of the power to turn the cylinder round its axis, is the same at whatever point in the axle it is fixed.

Prop. I.

92. In the wheel and axle the power and weight will be in equilibrium, when they are to one another reciprocally as the radii of the circles to which they are applied, or when the power is to the weight as the radius of the axle is to the radius of the wheel.

Fig. 11. Let AD be a section of the wheel, and BE a section of the axle or cylinder, and let the power P and weight W act in the directions AP, WP, tangents to the circumferences of the axle and wheel in the points A, B, by means of ropes winding round these circumferences. As the effect is the same according to the *axiom*, let the power and weight act in the same plane as they appear to do in the figure, then it is obvious that the effort of the power P and weight W will be the same as if they were suspended at the points A, B; consequently the machine may be regarded as a lever AFB, whose centre of motion is F. But since the directions of the power and weight make equal angles with the arms of the lever, we have (Art. 36.) $P : W = FB : FA$, that is, the power is to the weight as the radius of the axle is to the radius of the wheel.

Corollaries. 93. Cor. 1. If the power and weight act obliquely to the arms of the lever in the directions $A\,p$, $B\,w$, draw $F\,m$ $F n$ perpendicular to $A\,p$ and $B\,w$, and as in the case of the lever (Art. 51.) there will be an equilibrium when $P : W = F\,n : F\,m$. Hence the tangential direction is the most advantageous one in which the power can be applied, for FA is always greater than $F\,m$, and the least advantageous direction in which the weight can be applied, for it then opposes the greatest resistance to the power.

94. Cor. 2. If the plane of the wheel is inclined to the axle at any angle x, there will be an equilibrium when $P : W =$ semidiameter of the axle : sin. x.

95. Cor. 3. When the thickness of the rope is of a sensible magnitude, there will be an equilibrium when the power is to the weight as the sum of the radius of the axle, and half the thickness of its rope, is to the sum of the radius of the wheel and half the thickness of its rope; that is, if T be the thickness of the rope of the wheel, and t the thickness of the rope of the axle, there will be an equilibrium when $P : W = \overline{FB + \frac{1}{2}t} : \overline{FA + \frac{1}{2}T}$.

96. Cor. 4. If a number of wheels and axles are so combined that the periphery of the first axle may act on the periphery of the second wheel, either by means of a string or by teeth fixed in the peripheries of each, and the periphery of the second axle on the periphery of the third wheel, there will be an equilibrium when the power is to the weight as the product of the radii of all the axles is to the product of the radii of all the wheels. This corollary may be demonstrated by the some reasoning which is used in Art. 63. for the combination of Levers.

97. Cor. 5. In a combination of wheels, where the motion is communicated by means of teeth, the axle is called the *pinion*. Since the teeth therefore must be nearly of the same size, both in the wheel and pinion, the number of teeth in each will be as their circumferences, or as their radii; and consequently in the combination mentioned in the preceding corollary, the power will be to the weight, in the case of an equilibrium, as to the product of the number of teeth in all the pinions is to the product of the number of teeth in all the wheels.

Prop. II.

98. In the wheel and axle the velocity of the weight is to the velocity of the power as the power is to the weight.

If the power is made to rise through a space equal to the circumference of the wheel, the weight will evidently describe a space equal to the circumference of the axle. Hence, calling V the velocity of the power, v that of the weight, C the circumference of the wheel, and c that of the axle, we have $V : v = C : c$. But by the proposition $P : W = c : C$ therefore $P : W = v : V$.

Scholium.

99. The construction of the main-spring box of the fusee of a watch round which the chain is coiled, is a beautiful illustration of the principle of the wheel and axle. The spring-box may be considered as the wheel, and the fusee the axle or pinion to which the chain communicates the motion of the box. The power resides in the spring wound round an axis in the centre of the box, and the weight is applied to the lower circumference of the fusee. As the force of the spring is greatest when it is newly wound up, and gradually decreases as it unwinds itself, it is necessary that the fusee should have different radii, so that the chain may act upon the smallest part of the fusee when its force is greatest, and upon the largest part of the fusee when its force is least, for the equable motion of the watch requires that the inequality in the action of the spring should be counteracted so as to produce an uniform effect. In order to accomplish this, the general outline of the surface of the fusee must be an Apollonian hyperbola, in which the ordinates are inversely as their respective abscissæ. For further information on this subject, see *Recherches des Mathemat. par M. Parent*, tom. ii. p. 678.: *Traitè d'Horlogerie, par M. Berthoud*, tom. i. chap. 26.; and *Traitè de Mecanique, par M. de la Hire*, prop. 72. On the fusee of a watch.

Sect. II. *On the Pulley.*

100. Definition.—The pulley is a machine composed of a wheel with a groove in its circumference, and a rope which passes round this groove. The wheel moves on an axis whose extremities are supported on a kind of frame called the block, to which is generally suspended the weight to be raised. A system of pulleys is called a *muffle*, which is either fixed or moveable according as the block which contains the pulley is fixed or moveable. On the pulley.

Prop.

Theory.

Prop. I.

101. In a single pulley, or system of pulleys where the different portions of the rope are parallel to each other, and where one extremity of it is fixed, there is an equilibrium when the power is to the weight as unity is to the number of the portions of the rope which support the weight.

Fig. 12. 102. Case 1. In the single fixed pulley AA let the power P and weight W be equal, and act against each other by means of the rope PBAW, passing over the pulley AA; then it is obvious that whatever force is exerted by P in the direction PBA, the same force must be exerted in the opposite direction WBA, consequently these equal and opposite forces must be in equilibrio; and as the weight is supported only by one rope, the proposition is demonstrated, for P : W = 1 : 1.

Fig. 13. 103. Case 2. In the single moveable pulley, where the rope, fastened at H, goes beneath the moveable pulley D and over the fixed pulley C, the weight to be raised is suspended from the centre of the pulley D by the block *p*, and the power is applied at P in the direction PE. Now it is evident that the portions CF*p*, HGD of the rope sustain the weight W, and as they are equally stretched in every point, each must sustain one half of W; but (Case 1.) in the single pulley C the rope CEP sustains a weight equal to what the rope CF*p* sustains; that is, it sustains one-half of W. Consequently $P=\frac{1}{2}W$, or $W=2P$, when there is an equilibrium; and since the weight W is supported by *two* strings, we have P : W = 1 : 2.

Fig. 14. 15. 104. Case 3. When the same rope passes round a number of pulleys, the ropes which support the weight W are evidently equally stretched in every part, and therefore each of them sustains the same weight. Consequently if there be *ten* ropes supporting the weight, each sustains $\frac{1}{10}$th part of the weight, and therefore $P=\frac{1}{10}W$, or $W=10P$, which gives us P : W = 1 : 10. —The pulley in fig. 15. is the patent pulley invented by Mr White, in which the lateral friction and shaking motion is considerably removed.

Prop. II.

105. In a system of *n* moveable pulleys suspended by separate and parallel ropes, there is an equilibrium when $P : W = 1 : 2^n$; that is, if there are 4 pulleys $n=4$, and $P : W = 1 : 2\times2\times2\times2$, or P : W = 1 : 16.

Fig. 17. This system is represented in fig. 17. where the rope which carries the power P passes over the fixed pulley M, and beneath the moveable pulley A, to the hook E where it is fixed. Another rope fixed at A passes over B and is fixed at F, and so on with the rest. Then by Art. 103.

P : the weight at A = 1 : 2
The weight at A : the weight at B = 1 : 2
The weight at B : the weight at C = 1 : 2
The weight at C : the weight at D or W = 1 : 2; and therefore by composition
$P : W = 1 : 2\times2\times2\times2$ or P : W = 1 : 16. Q. E. D.

Prop. III.

106. In a system of moveable pulleys whose number is *n*, suspended by separate and parallel ropes, whose extremities are fixed to the weight W, there is an equilibrium when $P : W : 1 : 2^n - 1$.

In this systemof pulleys, the rope which sustains the Fig. 18. power P passes over the pulley C, and is fixed to the weight at D. Another rope attached to the pulley C passes over the pulley B and is fixed to the weight at E, and a third rope fastened to B passes over A and is fixed at F. Then it is manifest that the rope CD sustains a weight equal to P; and since the pulley C is pulled downward with a weight equal to 2P, the rope BC must support a weight equal to 2P, and the rope B the same weight; consequently the rope AB sustains 4P. The whole weight therefore is $P+2P+4P$; and hence $P : W = P : P+2P+4P$, or $P : W = 1 : 1+2+4$ &c. to *n* terms, so that $P : W = 1 : 2^n - 1$.

Prop. IV.

107. In the system of pulleys represented in Fig. 19. fig. 19. and called a Spanish barton, in which two pulleys are supported by one rope, there is an equilibrium when P : W = 1 : 4.

In this combination of pulleys, the rope AB which supports the power P passes over the moveable pulley A, and beneath C towards H, where it is fixed. Another rope, attached to the pulley A, passes over the fixed pulley B, and is fastened at E to the pulley C, which supports the weight W. Then, since the rope AP supports 1 pound, the rope AC also supports 1 pound, and therefore the pulley A, or the rope BA, is pulled down with a force of 2 pounds. But the rope BDE is equally stretched with BA, consequently the pulley C, to which DE is attached, is pulled upwards with a force of 2 pounds. Now the rope AC supporting 1 pound, the rope GH must likewise support 1 pound, consequently, since DE sustains 2 pounds, AC 1 pound, and HG 1 pound, they will together sustain W=4 pounds, and therefore P : W = 1 : 4.

Prop. V.

108. In the system of pulleys represented in fig. Fig. 20. 20. called a Spanish barton, where two pulleys are supported by one rope, there is an equilibrium when P : W = 1 : 5.

In this system the rope PB passes over B round C, and is fixed at E. Another rope attached to B passes round AF and is fixed at I to the pulley CD, which carries the weight W. Now the rope BP being stretched with a force of 1 pound, the ropes BGC, CDE are also stretched with a force of 1 pound each, and the pulley CD is pulled upwards with a force of 2 pounds. But since the three ropes BP, ED, and GC, are each stretched with a force of 1 pound, the pulley B and the rope BA, upon which they all act in one direction, must be pulled down with a force of 3 pounds. Now the rope FI is equally stretched with BA, consequently it will draw the pulley CD upwards with a force of 3 pounds, Theory. pounds, and since it is drawn upwards by the ropes CG, DF, with a force of two pounds, the whole force will sustain $W=5$ pounds; but this force of 5 pounds is by the hypothesis in equilibrio with P or 1 pound, consequently $P : W = 1 : 5$.

Prop. VI.

Plate CCCXIX. fig. 1. 109. **When the ropes are not parallel, and when two powers are in equilibrio with a weight by means of a pulley, and have their directions at equal angles to the direction of the weight, each of these powers is to the weight as the radius of the pulley is to the chord of that portion of the pulley's circumference with which the rope is in contact.**

Let the weight W suspended from C be sustained in equilibrio by two powers, P, p, which act by a rope PCFEp passing over the pulley CHEF, and touching the arch CFE of its circumference. Then since the angles PWD, pWD are equal, and the powers P, p in equilibrio, P must be equal to p; and making WA $=$WB, and drawing AI parallel to PW, and BI parallel to pW; WB, BI, WI will respectively represent the forces P, p, W or $P : p : W = WB : BI : WI$, Dynamics, Art. 144. Now the triangles WBI, BDE having their respectives sides at right angles to each other, are similar; consequently $WB : BI : WI = CD : DE : EC$, that is, $P : p : W = CD : DE : EC$; but CD, DE are equal to radius, and EC is obviously the chord of the arch CFE, therefore P : W or p : W as radius is to the chord of the arch with which the rope is in contact.

110. Cor. 1. Any of the powers is also to the weight as radius is to twice the cosine of the angle which either rope makes with the direction of the weight. For since CG is the cosine of DCG, and since CE is double of CG, CE is equal to 2 cosine DCG $=2$ Cos. PWD; but $P : W = CD : CE$, hence we have by substituting the preceding value of CE, $P : W = CD$ or radius : 2 Cos. PWD.

Scholium.

111. By means of this proposition and corollary, the proportion between the powers and the weight in the various systems of pulleys, represented in fig. 12, 13, 14, 15, 16, 17, 18, 19, 20. when the ropes are not parallel, may be easily found.

Prop. VII.

112. **In a system of moveable pulleys, where each has a separate rope, and where the ropes are not parallel, there is an equilibrium when the power is to the weight as radius is to the cosines of half the angles made by the rope of each pulley, multiplied into that power of 2 whose exponent is the number of pulleys.**

Fig. 2. Let the power P sustain the weight W by means of the pulleys A, B, C; let P, p, π be the different powers which support the pulleys, A, B, C, and let MAP, NBA, RCB be the angles formed by the ropes. Then, by the last proposition,

$$P : p = \text{rad.} : 2 \cos. MAP$$
$$p : \pi = \text{rad.} : 2 \cos. NBA$$
$$\pi : W = \text{rad.} : 2 \cos. RCB, \text{ consequently}$$ Theory.
$$P : W = \text{rad.} : \overline{2 \cos. MAP \times 2 \cos. NBA \times 2 \cos. RCB},$$

or, which is the same thing,

$$P : W = \text{rad.} : \overline{2 \times 2 \times 2} \times \cos. MAP \times \cos. NBA \times \cos. RCB.$$

Prop. VIII.

113. **In a single pulley, or in a combination of pulleys, the velocity of the power is to the velocity of the weight as the weight is to the power.**

114. Case 1. In the single fixed pulley, it is obvious, that if the weight W is raised uniformly one inch, the power D will also describe one inch, consequently velocity of P : velocity of $W = W : P$. Fig. 12.

115. Case 2. In the single moveable pulley, when the weight W is raised one inch, the ropes become one inch shorter; and since the rope has always the same weight, the power must describe two inches, therefore velocity P : velocity $W = W : P$. Fig. 13.

116. Case 3. In the combination of pulleys, in figs. 14, 15, 16, when the weight rises one inch, each of the four strings becomes an inch shorter, so that P must describe four inches, as the length of the rope is invariable; consequently velocity P : velocity $W = W : P$. Figs. 14, 16.

117. Case 4. In the system exhibited in fig. 17. it is evident, that when the weight W rises one inch, the rope DC is lengthened two inches, the rope CB four inches, the rope BA eight inches, and the rope AFP, to which the power is suspended, 16 inches; so that since the power of this pulley is as 16 to 1, we have velocity P : velocity $W = W : P$. Fig. 17.

118. Case 5. In the combination of pulleys, represented in fig. 18. when the weight W rises one inch, all the three ropes CD, BE, AF are each shortened one inch. But while CD shortens one inch, CP becomes *one inch longer*; while BE shortens one inch, BC becomes one inch longer, and CP *two inches* longer (art. 110.); and while AF shortens one inch, AB becomes one inch longer, BC two inches longer, and CP *four inches* longer; therefore CP is lengthened altogether seven inches, and as the power of the pulley is as 7 to 1, we have, as before, velocity P : velocity $W = W : P$. Fig. 18.

119. Case 6. In the system of pulleys called the Spanish barton, fig. 19. when the weight W rises one inch, the three ropes AC, DE, HG are each shortened one inch. By the shortening HG, CA one inch each, the rope AP is lengthened *two inches;* and by the shortening of DE one inch, BA is lengthened one inch, and AP *two inches* (art. 115.); consequently since AP is lengthened in all four inches, and since the power of the pulleys is four, we have velocity P : velocity $W = W : P$. Fig. 19.

120. Case 7. In the other Spanish barton, in fig. 20. when the weight is elevated one inch, the three ropes DE, IF, CG are each one inch shorter. While ED, and CG shorten one inch each, BP is lengthened *two inches,* Fig. 20.

Theory.

inches, and while IF becomes one inch shorter, AB becomes one inch longer; but when AB is lengthened one inch, BP becomes one inch longer, and ED, CG one inch shorter each, and by this shortening of ED, CG, the rope B is lengthened two inches, therefore, since the rope BP is lengthened altogether five inches, and since the pulleys have a power of five, we have, as formerly, velocity P : velocity W=W : P.

Sect. III. *On the Wedge.*

121. Definition. A wedge is a machine composed of two inclined planes with their bases in contact; or, more properly, it is a triangular prism, generated by the motion of a triangle, parallel to itself, along a straight line passing through the vertex of one of its angles. The wedge is called *isosceles*, *rectangular*, or *scalene*, according as the triangle ABC by which the wedge is generated, is an isosceles, a rectangular or a scalene triangle. The part AB is called the head or back of the wedge, DC its altitude, and AC, BC its faces.—The wedge is generally employed for cleaving wood, or for quarrying stones; but all cutting instruments, such as knives, swords, chisels, teeth, &c. properly belong to this mechanical power, when they act in a direction at right angles to the cutting surface; for when they act obliquely, in which case their power is increased, their operation resembles more the action of a saw.

Plate CCXIX. fig. 3.

Prop. I.

122. If each of the faces of an isosceles wedge, which are perfectly smooth, meet with an equal resistance from forces acting at equal angles of inclination to their faces, and if a power act perpendicularly upon the back, these forces will be in equilibrio, when the power upon the back is to the sum of the resistances upon the sides, as the sine of half the angle of the wedge, multiplied by the sine of the angle at which the resisting forces act upon its faces, is to the square of radius.

Fig. 3.

Let ABC be the wedge, AC, BC its acting faces, and MD, ND the directions in which the resisting forces act upon these faces, forming with them the equal angles DMA, DNB. Draw CD, DF, DE at right angles to three sides of the wedge, and join F, E meeting CD in G. On account of the equal triangles CAD, CDB (Euclid, Book i. Prop. 26.) AD=DB; and in the equal triangles ADM, BDN, MD=ND. In the same way DF=DE and AF=BE, therefore CF=CE. But in the triangles CFG, CEG there are two sides FC, CG equal to EC,CG, and the angle FCG=ECG, consequently FG=GE, and FGC, ABC are both right angles, therefore FE is parallel to AB.—Now the force MD is resolvable into DF, FM, of which FM has no effect upon the wedge. But, as the effective force FD is not in direct opposition to the perpendicular force exerted on the back of the wedge, we may resolve it into the two forces FG, GD, of which GD acts in direct opposition to the power, while FG acts in a direction parallel to the back of the wedge. In the same way it may be shewn that EG, GD are the only effective forces which result from the force ND. But the forces FG, EG being equal and opposite, destroy each other; consequently 2GD is the force which opposes that which is excited upon the back of the wedge, and the wedge will be kept at rest if the force upon the back is equal to 2GD, that is, when the force upon the back is to the sum of the resistances upon the faces as 2GD is to MD+ND, or as 2GD : 2DM, or as GD is to DM. Now

DG : DF=sin. DFG : radius, or as (Euclid, vi. 8.) sin. DCF : radius, and
DF : MD=sin. DMF : radius; therefore by composition,
DG : MD=sin. DCF × sin. DMF : rad. × rad. or $\overline{\text{rad.}}|^2$. But, DG : MD as the force upon the back is to the sum of the resistances, therefore the force upon the back is to the sum of the resistances, as sin. DCF × sin. DMF is to the square of the radius.

Corollaries.

123. Cor. 1. If the direction of the resisting forces is perpendicular to the faces of the wedge, DMF becomes a right angle, and therefore its sine is equal to radius. Consequently we have, in this case, the force upon the back to the sum of the resistances, as sin. DCF × rad. is to $\overline{\text{radius}}|^2$, that is, as sin DCF is to radius, or as AD half the back of the wedge is to AC the length of the wedge.

124. Cor. 2. In the particular case in the proposition, it is obvious that the forces MF, NE are not opposed by any other forces, and therefore the force upon the back will not sustain the resisting forces; but in the case in cor. 2. the forces MF, NE vanish, and therefore the other forces will sustain each other.

125. Cor. 3. If the resisting forces act in a direction perpendicular to AB, the angle DMF becomes equal to ACD, and therefore the force upon the back is to the sum of the resistances as sin. $\overline{\text{ACD}}|^2$ is to $\overline{\text{radius}}|^2$, that is, as the square of AD half the back of the wedge is to the square of AC the length of the wedge.

126. Cor. 4. When the direction of the resistances is parallel to the back of the wedge, the angle of inclination DMC becomes the complement of the semi-angle of the wedge, and therefore the force upon the back is to the sum of the resistances as the sin. ACD × cos. ACD is to the square of the radius, that is, as DA × DC is to $\overline{\text{AC}}^2$. But in the similar triangles DAF, DAC, we have DF : DA=DC : AC, and DF × AC=DA × DC, consequently the force upon the back of the wedge is to the sum of the resistances as DF × AC is to $\overline{\text{AC}}^2$, that is, as DF : AC.

Prop. II.

127. If, on account of the friction of the wedge, or any other cause, the resistances are wholly effective, that is, if the resisting surfaces adhere to the places to which they are applied without sliding, there will be an equilibrium, when the force upon the back is to the sum of the resistances, as the sine of the acute angle which the direction of the resisting forces makes with the back of the wedge is to radius. Fig. 3.

Join MN, which will cut DC perpendicularly at the point

Theory. point H. Then, since the forces MD, ND are resolvable into MH, HD and into NH, HD, and since MH, HN destroy each other, the force upon the back is sustained by 2 HD. Consequently, the force upon the back is to the sum of the resistances as 2 HD is to 2 MD, or as HD is to MD. But the angle ADM, which the direction of the forces makes with the back of the wedge, is equal to DMN, and HD is the sine of that angle, MD being radius, therefore the force upon the back is to the sum of the resistances as sin. ADM : radius. Q. E. D.

Corollaries. 128. Cor. 1. Since the angle AMD=MDC+MCD, the angle MDC is the difference between MCD the semiangle of the wedge, and AMD the angle which the direction of the resisting forces makes with the face of the wedge, and since HD is the cosine of that angle, MD being radius, we have the force upon the back to the sum of the resistances, as the cosine of the difference between the semiangle of the wedge and the angle which the direction of the resisting forces makes with the face of the wedge, is to radius.

Prop. III.

129. When there is an equilibrium between three forces acting perpendicularly upon the sides of a wedge of any form, the forces are to one another as the sides of the wedge.

This is obvious from Dynamics, § 144. Cor. 2. where it is shewn that when three forces are in equilibrio, they are proportional to the sides of a triangle, which are respectively perpendicular to their directions.

Prop. IV.

130. When the power acting upon the back of a wedge is in equilibrio with the resistances opposed to it, the velocity of the power is to the velocity of the resistance as the resistance is to the power.

Fig. 3. Produce DM to K, and draw CK perpendicular to DK. Then, by Art. 122. the power is to the resistance as MD : DH. Let the wedge be moved uniformly from D to C, and DK is the space uniformly described by the resisting force in the direction in which it acts; therefore, the velocity of the power is to the velocity of the resistance as DC : DK; that is, on account of the equiangular triangles DHM, DKC, as MD : DH; that is, as the resistance is to the power.

Sect. IV. *On the Screw.*

131. Definition. A screw is a cylinder with an inclined plane wrapped round it, in such a manner, that the surface of the plane is oblique to the axis of the cylinder, and forms the same angle with it in every part of the cylindrical surface. When the inclined plane winds round the exterior surface of a solid cylinder, it is called a male screw; but when it is fixed on the interior circumference of a cylindrical tube, it is called a female screw. In the female screw, the spiral grooves formed by the inclined plane on the surface of the cylindrical tube, must be equal in breadth to the inclined plane in the male screw, in order that the one may move freely in the other. By attending to the mode in which the spiral threads are formed by the circumvolution of the inclined plane, it will appear, that if one complete revolution of the inclined plane is developed, its altitude will be to its base as the distance between the threads is to the circumference of the screw. Thus, let $a\,b\,c$ (fig. 4.) be the inclined plane, whose base is $a\,c$ and altitude $b\,c$, and let it be wrapped round the cylinder MN (fig. 5.) of such a size that the points a, c may coincide. The surface $a\,b$ of the plane (fig. 4.) will evidently form the spiral thread $a\,d\,e\,b$ (fig. 5.), and ab the distance between the threads will be equal to $b\,c$ (fig. 4.) the altitude of the plane, and the circumference of the screw MN will be equal to $a\,c$ the base of the plane. If any body, therefore, is made to rise along the plane $a\,d\,e\,b$ in fig. 5. or along the spiral thread of the screw, by a force acting in a direction parallel to $a\,d\,c\,b$, there will be the same proportion between the power and the resistance as if the body ascended the plane $a\,b\,c$ (fig. 4.). Fig. 4

132. A male screw with triangular threads is represented by AB (fig. 6.), and its corresponding female screw by AB (fig. 7.). A male screw with quadrangular threads is exhibited in fig. 8. and the female screw in which it works in fig. 9. The friction is considerably less in quadrangular than in triangular threads, though, when the screw is made of wood, the triangular threads should be preferred. When the screws are metallic and large, the threads should be quadrangular; but the triangular form is preferable in small screws. When the screw is employed in practice, the power is always applied to the extremity of a lever fixed in its head. This is shewn in fig. 10. where AB is the lever acting upon the screw BC, which works in a female screw in the block F, and exerts its force in bending the spring CD. Fig. 6, 7. Fig. 8, 9. Fig. 10.

Prop. I.

133. If the screw is employed to overcome any resistance, there will be an equilibrium when the power is to the resistance as the distance between two adjacent threads is to the circumference described by the power.

Let FAK be a section of the screw represented in fig. 8. perpendicular to its axis; CD a portion of the inclined plane which forms the spiral thread, and P the power, which, when applied at C in the plane ACF, will be in equilibrium with a weight upon the inclined plane CD. Then, in the inclined plane, when the direction of the power is parallel to the base, we have (Art. 72.) P : W, as the altitude of the plane is to the base, or (Art. 131.) as the distance between two threads is to the whole circumference FKCF. If we suppose another power P′ to act at the end of the lever AB, and describe the arch HBG, and that this power produces the same effect at B as the power P did at C, then (Art. 36.), we have P′ : P=CA : BA, that is, as FKCF is to the circumference HBG; but it was shewn before, that P : W=as the distance between two contiguous threads is to FKCF; therefore, by composition, P′ : W as the distance between two threads is to HBG or the circumference of a circle whose radius is AB. Q. E. D. Fig. 11.

134. Cor. 1. It is evident from the proposition that the

Theory.

the power does not in the least depend upon the size of the cylinder FCK, but that it increases with the distance of that point from the centre A, to which the power is applied, and also with the shortness of the distance between the threads. Therefore, if P, p be the powers applied to two different screws, D, d the distances of these powers from the axis, and T, t the distances between the threads; their energy in overcoming a given resistance will be directly as their distances from the axis, and inversely as the distances of their threads, that is, $P:p=\frac{D}{T}:\frac{d}{t}$, or P varies as $\frac{D}{T}$.

Prop. II.

135. In the endless screw, there will be an equilibrium when the power is to the weight, as the distance of the threads multiplied by the radius of the axle, is to the distance of the power from the axis of the screw multiplied by the radius of the wheel.

Fig. 12.

The endless screw, which is represented in fig. 12. consists of a screw EF, so combined with the wheel and axle ABC, that the threads of the screw may work in teeth fixed in the periphery of the wheel, and thus communicate the power exerted at the handles or winches P, p. Let W′ represent the power produced by the screw at the circumference of the wheel; then, by the last proposition, P : W′ as the distance between the threads is to the distance of P from the axis of the screw; but (Art. 92.) in the wheel and axle W′ : W as the radius of the axle is to the radius of the wheel; therefore, by composition, P : W as the distances of the threads multiplied by the radius of the axle C, is to the distance of the power P from the axis multiplied by the radius of the wheel AB.

Prop. III.

136. When there is an equilibrium in the screw, the velocity of the weight is to the velocity of the power, as the power is to the weight.

Fig. 11.

It is obvious from fig. 11. that while the power describes the circumference of the circle HBG uniformly, the weight uniformly rises through a space equal to the distance between two adjacent threads; therefore, the velocity of the power is to the velocity of the weight as the distance between the threads is to the arch described by the power, that is, (by Art. 133.), as the weight is to the power.

Prop. IV.

137. To explain the construction and advantages of Mr Hunter's double screw *.

See *Phil. Trans.* vol. lxxi. p. 58.

Fig. 13.

Let the screw CD work in the plate of metal BA, and have n threads in an inch: the cylinder CD, of which this screw is formed, is a hollow tube, which is also formed into a screw, having $\overline{n+1}$ threads in an inch, and into this female screw is introduced a male screw DE, having, of course, $\overline{n+1}$ threads in an inch. The screw DE is prevented from moving round with CD by the frame ABGF and the cross bar $a\ b$, but is permitted to ascend and descend without a motion of rotation. Then, by a revolution of the screw CD, the other screw DE will rise through a space equal to $\frac{1}{\overline{n+1}\times n}$, and if the circumference described by the lever CK be m inches, we shall have $P:W=\frac{1}{\overline{n+1}\times n}:m$; or $P:W=1:mn\times\overline{n+1}$.

138. This reasoning will be more perspicuous by supposing n, or the number of threads in CD, to be 12, and $n+1$, or the number of threads in DE, will consequently be 13. Let us suppose that the handlo CK is turned round 12 times, the screw CD will evidently ascend through the space of an inch, and if the screw DE is permitted to have a motion of rotation along with CD, it will also advance an inch. Let the screw DE be now moved backwards by 12 revolutions, it will evidently describe a space of $\frac{12}{13}$ of an inch, and the consequence of both these motions will be that the point E is advanced $\frac{1}{13}$ of an inch. But, since DE is prevented from moving round with CD, the same effect will be produced as if it had moved 12 times round with CD, and had been turned 12 times backwards; that is, it will in both cases have advanced $\frac{1}{13}$ of an inch. Since, therefore, it has advanced $\frac{1}{13}$ of an inch in 12 turns, it will describe only $\frac{1}{12}$ of $\frac{1}{13}$, or $\frac{1}{156}$ of an inch uniformly at one turn; but if the length of the lever CK is 8 inches, its extremity K will describe, in the same time, a space equal to $16\times3.1416=50.2656$ inches, the circumference of the circle described by K; therefore the velocity of the weight is to the velocity of the power, as $\frac{1}{156}$ of an inch is to 50.2656 inches, or as 1 is to 7841.4336, that is, (Art. 136.) P : W $=1:7841.4336$. Hence the force of this double screw is much greater than that of the common screw, for a common one with a lever 8 inches long must have 156 threads in an inch to give the same power, which would render it too weak to overcome any considerable resistance.

139. Mr Hunter proposes * to connect with his double screws, a wheel and a lantern, which are put in motion by a winch or handle. The power of this compound machine is so great, that a man, by exerting a force of 32 pounds at the winch, will produce an effect of 172100 pounds; and if we suppose $\frac{2}{3}$ of this effect to be destroyed by friction, there will remain an effect of 57600 pounds.—In some screws it would be advantageous, instead of perforating the male screw CD, to have two cylindrical screws of different kinds at different parts of the same axis.

* *Phil. Trans.* vol. lxxi. p. 65.

Scholium.

140. The screw is of extensive use as a mechanical power, when a very great pressure is required, and is very successfully employed in the printing press. In the press which is used for coining money, the power of the screw is advantageously combined with an impulsive force, which is conveyed to the screw by the intervention of a lever. The screw is also employed for raising water, in which form it is called the screw of Archimedes (Hydrodynamics, § 328); and it has been lately employed in the flour mills in America for pushing the flour which comes from the millstones, to the end of a long trough, from which it is conveyed to other parts of

Theory. of the machinery, in order to undergo the remaining processes. In this case, the spiral threads are very large in proportion to the cylinder on which they are fixed.

141. As the lever attached to the extremity of the screw moves through a very great space when compared with the velocity of its other extremity, or of any body which it puts in motion; the screw is of immense use in subdividing any space into a great number of minute parts. Hence it is employed in the engines for dividing mathematical instruments, and in those which have been recently used in the art of engraving. It is likewise of great use in the common wire micrometer, and in the divided object-glass micrometer, instruments to which the science of astronomy has been under great obligations. See Micrometer.

Sect. V. *On the Balance.*

Plate CCCXX. Fig. 1. 142. Definition. The balance, in a mathematical sense, is a lever of equal arms, for determining the weights of bodies.—The physical balance is represented in fig. 1. where FA, FB are the equal arms of the balance, F its centre of motion situated a little above the centre of gravity of the arms, FD the handle which always retains a vertical position, P, W the scales suspended from the points A, B, and CF the tongue or index of the balance, which is exactly perpendicular to the beam AB, and is continued below the centre of motion, so that the momentum of the part below F is equal and opposite to the momentum of that part which is above it. Since the handle FD, suspended by the hook H, must hang in a vertical line, the tongue CF will also be vertical when its position coincides with that of FD, and consequently the beam AB, which is perpendicular to CF, must be horizontal. When this happens, the weights in the scale are evidently equal. Theory.

Prop. I.

143. To determine the conditions of equilibrium in a physical balance.

Let AOB be the beam, whose weight is S, and let P, Q be equal weights expressed by the letter p, and placed in the scales, whose weights are L and l. Let O be the centre of motion, and g the centre of gravity of the whole beam, when unloaded; we shall have in the case of an equilibrium, Fig. 2.

I. $\overline{p+L}\times AC=\overline{p+l}\times BC+\overline{S\times Cc}$; for since S is the weight of the beam and g its centre of gravity, its mechanical energy in acting against the weights $p+L$ is $=S\times Cc$, the distance of its centre of gravity from the vertical line passing through the centre of motion O.

II. But since $AC=BC$; $p\times\overline{AC}-p\times BC=0$. Then, after transposition, take this from the equation in N° I. and we shall have,

III. $l\times BC-L\times AC+S\times Cc$; or $L-l=\frac{S\times Cc}{AC}$.

Let us now suppose that a small weight w is placed in the scale L, the line AB which joins the points of suspension will be no longer horizontal, but will assume an inclined position. Let $BA\lambda=\varphi$ be the angle which the beam makes with the direction of gravity. Then by resolving the weight of the beam which acts in the direction O z, the parts $\frac{OG}{Og}$ and $\frac{Gg}{Og}$ will be in equilibrio, and we shall have,

$$\text{IV. } \overline{p+L}\times AO\times\text{Sin.}\,\lambda AO+S\times OG\times\text{Sin.}\,\varphi=\overline{p+l+w}\times BO\times\text{Sin. }ABO+S\times Cc\times\text{Cos.}\,\varphi.$$

But since the sines and cosines of any angles, are the same as the sines and cosines of their supplement, we have,

$$\text{V. } \overline{p+L}\times\overline{AC\times\text{Cos.}\varphi-Oc\times\text{Sin.}\varphi}+S\times OG\times\text{Sin.}\varphi=\overline{p+l+w}\times\overline{AC\times\text{Cos.}\varphi+OC\times\text{Sin.}\varphi}+S\times Cc\times\text{Cos.}\varphi.$$

Hence by N° III. we have,

$$\text{VI. Tang.}\,\varphi=\frac{w\times AC}{\overline{2p+L+l+w}\times OC+S\times OG}$$

But the force v, with which the balance attempts to recover its horizontal situation, is the excess of momenta with which one arm is moved, above the momenta with which the other arm is moved, therefore

$$v=\overline{2p+L+l}\times OC\times\text{Sin.}\varphi+S\times OG\times\text{Sin.}\varphi.$$

144. A more extended illustration of these conditions of equilibrium will be found in an excellent paper by Euler, published in the *Comment. Petropol.* tom. x. p. 1. and in another memoir upon the same subject by Kuhne in the *Versuche der naturforchende gesellchhaft* in Dantzig, tom. i. p. 1.—See also Hennert's *Cursus Matheseos applicatæ*, tom. i. § 123. From the preceding formulæ, the following practical corollaries may be deduced.

145. Cor. 1. The arms of the balance must be exactly equal in length, which is known by changing the weights in the scales; for if the equilibrium continues, the arms must be equal.

146. Cor. 2. The sensibility of the balance increases with the length of the arms.

147. Cor. 3. If the centre of motion coincides with the point C and the centre of gravity, the balance will be in equilibrio in any position, and the smallest weight added to one of the scales will bring the beam into a horizontal position. The centre of motion, therefore, should not coincide with the centre of gravity.

148. Cor. 4. If the centre of motion is in the line which joins the points of suspension, the accuracy of the balance will be increased. The excess of the weights may be easily determined by the inclination of the beam, pointed out by the tongue or index upon a circular arch fixed to the handle, or more accurately by means of two divided arches fixed near the points of suspension, on a stand independent of the balance. When the value of one of these divisions is determined experimentally, the rest are easily found, being proportional to the tangents of the inclination of the beam.

heory.

149. COR. 5. The sensibility of the balance will increase, the nearer that the centre of gravity approaches to the centre of motion.

150. COR. 6. If the centre of gravity is above the centre of motion, the balance is useless.

SCHOLIUM.

151. A balance with all the properties mentioned in the preceding corollaries, has been invented by M. Kuhne, and described in the work already quoted (Art. 144.). It is so contrived that the points of suspension may be placed either above the centre of motion or below it, or in the line of its axis: the beam is furnished with an index, which points out the proportion of the weights upon a divided scale, and the friction of the axis is diminished by the application of friction wheels.

hne's ance.

152. In order to get rid of the difficulties which attend the construction of the tongue, the handle, and the arms of the balance, M. Magellan invented a very accurate and moveable one, in which there is no handle, and where one of the arms acts as a tongue. The body to be weighed and the counterpoise are placed in the same scale, so that it is of little consequence whether the arms of the balance are equal or not. In this balance the centre of motion can be moved to the smallest distance from the centre of gravity. See *Journal de Physique*, Jan. 1781. tom. xvii. p. 43.

gellan's ance.

153. The balance invented by Ludlam, and described in the Philosophical Transactions for 1765, N° 55. depends upon Æpinus's property of the lever, which we have explained in Art 65. The angular lever AFB, in which AF=FB, is moveable round f, which is equidistant from A and B. The weight P is suspended by a thread from A, and the body W, which is to be weighed, is suspended by a thread from B. Hence it is obvious, that with different bodies the lever AFB will have different degrees of inclination, and the index or tongue LFf, which is perpendicular to AB, will form different angles ZFL, bFf with the line of direction ZFb. Now, by Art. 57. and by substituting for bB, bA the sines of the angles FbB, FbA, to which they are proportional, and also by taking instead of FbB the difference of the angles fFB, fFb, and instead of AFb, the sum of these angles, we shall have

dlam's lance. Plate CXVIII. fig. 3.

$$\text{Tang}, fFb=\frac{P-W}{P+W}\times\text{Tang.}\frac{AFB}{2},$$

whence, by transposition, and by GEOMETRY, Theor. VIII. Sect. IV.

$$\overline{P+W}:\overline{P-W}=\text{Tang.}\frac{AFB}{2}:\text{Tang.}\,fFb.$$

Hence, when the angle formed by the arms of the balance, and the angle of aberration fFb or ZFL, are known, the weights may be found, and *vice versa*.

CHAP. IV. *On the centre of Inertia, or Gravity.*

154. DEFINITION.—The centre of inertia, or the centre of gravity, of any body or system of bodies, is that point upon which the body or system of bodies, when influenced only by the force of gravity, will be in equilibrio in every position. The centre of inertia of plane surfaces bounded by right lines, and also of some solids may be easily determined by the common geometry. The application of the method of fluxions, however, to this branch of mechanics is so simple and beautiful, that we shall also avail ourselves of its assistance. The centre of gravity has been called, by some writers, the centre of position, and by others, the centre of mean distances.

Theory.

PROP. I.

155. To find the centre of inertia of any number of bodies, whatever be their position.

Let ABCD be any number of bodies influenced by the force of gravity. Suppose the bodies A, B connected by the inflexible line AB considered as devoid of weight, then find a point F, so that the weight of A : the weight of B=BF : FA. The bodies A, B will therefore be in equilibrio about the point F in every position (Art. 36.), and the pressure upon F will be equal to A+B. Join FC, and find the point f, so that A+B : C=Cf : fF; the bodies A, B, C, will consequently be in equilibrio upon the point f, which will sustain a pressure equal to A+B+C. Join Df, and take the point φ, so that A+B+C : D=φD : φf; the bodies A, B, C, D will therefore be in equilibrio about the point φ, which will be their common centre of inertia, and which supports a weight equal to A+B +C+D. In the same manner we may find the centre of inertia of any system of bodies, by merely connecting the last fulcrum with the next body by an inflexible right line, and finding a new fulcrum from the magnitude of the opposite weights which it is to sustain. Fig. 4.

156. COR. 1. If the weights of the bodies A, B, C, D be increased or diminished in a given ratio, the centre of inertia of the system will not be changed, for the positions of the points F, f, φ are determined by the relative and not by the absolute weights of the bodies.

157. COR. 2. A motion of rotation cannot be communicated to a body by means of a force acting upon its centre of inertia; for the resistances which the inertia of each particle opposes to the communication of motion act in parallel directions, and as they are proportional to the weights of the particles, they will be in equilibrio about the centre of gravity.

PROP. II.

158. To find the centre of inertia of any number of bodies placed in a straight line.

Let A, B, C, D, E be any number of bodies whose common centre of gravity is φ. In the straight line AE take any point X. Then since all the bodies are in equilibrio about their common centre of gravity φ, we have by the property of the lever (Art. 36.) $\overline{A\times A\varphi}+\overline{B\times B\varphi}=C\times C\varphi+\overline{D+D\varphi}+\overline{E\times E\varphi}$; but since $X\varphi-XA=A\varphi$, and $X\varphi-XB=B\varphi$, and so on with the rest, we have by substitution $A\times\overline{X\varphi-XA}+B\times\overline{X\varphi-XB}=C\times\overline{X\varphi-XC}+D\times\overline{X\varphi-XD}+E\times\overline{X\varphi-XE}$. Hence, by multiplying and transposing, we obtain $\overline{A\times X\varphi}+\overline{B\times X\varphi}+\overline{C\times X\varphi}+\overline{D\times X\varphi}+E\times X\varphi=\overline{A\times XA}+\overline{B\times XB}+\overline{C\times XC}+\overline{D\times XD}+E\times XE$, then dividing by A+B+C+D+E, we have Fig. 5.

Xφ

$$X\varphi = \frac{\overline{A\times XA}+\overline{B\times XB}+\overline{C\times XC}+\overline{D\times XD}+\overline{E\times XE}}{A+B+C+D+E}.$$

Now $A\times XA$, $B\times XB$, &c. are evidently the momenta of the bodies A, B, &c. and the divisor $A+B+C+D+E$ is the sum of the weights of all the bodies; therefore the distance of the point X from the centre of gravity φ is equal to the sum of the momenta of all the weights divided by the sum of the weights.

159. Cor. 1. If the point X had been taken between A and E, at x for example, then the quantity $A\times XA$ would have been reckoned negative, as lying on a different side of the point X.

160. Cor. 2. From this proposition we may deduce a general rule for finding the centre of gravity in any body or system of bodies. Let any point be assumed at the extremity of the system, then the product of the momenta of all the bodies, (or the product arising from the continual multiplication of each body by its distance from the point), divided by the sum of the weights of all the bodies, will be a quotient which expresses the distance of the centre of gravity from the point assumed.

Prop. III.

161. If, in a system of bodies, a perpendicular be let fall from each upon a given plane, the sum of the products of each body multiplied by its perpendicular distance from the plane, is equal to the sum of all the bodies multiplied by the perpendicular distance of their common centre of inertia from the given plane.

Fig. 6. Let A, B, C be the bodies which compose the system, and MN the given plane; by Art. 155. find F the centre of inertia of A and B, and G the centre of gravity of the three bodies; and from A, F, B, G, C draw Aa, Ff, Bb, Gg, Cc perpendicular to the plane MN. Through F draw xFy, meeting Aa produced in x, and Bb in y, then in the similar triangles AxF, ByF, we have $Ax : By = AF : BF$, that is, (Art. 155.) as $B : A$, hence $A\times Ax = B\times By$, that is, $A\times\overline{xa-Aa} = B\times\overline{Bb-yb}$, or on account of the equality of the lines xa, Ff, Bb; $A\times\overline{Ff-Aa} = B\times\overline{Bb-Ff}$, therefore, by multiplying and transposing, we have $\overline{A+B}\times Ff = \overline{A\times Aa}+\overline{B\times Bb}$. In the very same way, by drawing wGz parallel to the plane, it may be shewn that $\overline{A+B+C}\times Gg = A\times Aa + B\times Bb + C\times Cc$. Q. E. D.

162. Cor. By dividing by $A+B+C$ we have

$$G = \frac{\overline{A\times Aa}+\overline{B\times Bb}+\overline{C\times Cc}}{A+B+C}.$$

Prop. IV.

163. To find the centre of inertia of a straight line, composed of material particles.

If we consider the straight line as composed of a number of material particles of the same size and density, it is evident that its centre of inertia will be a point in the line equidistant from its extremities. For if we regard the line as a lever supported upon its middle point as a fulerum, it will evidently be in equilibrio, in every position, as the number of particles or weights on each side of the fulcrum is equal.

Prop. V.

164. To find the centre of inertia of a parallelogram.

Let ABCD be a parallelogram of uniform density, bisect AB in F, and having drawn Ff parallel to AC or BD, bisect it in φ; the point φ will be the centre of inertia of the parallelogram. The parallelogram may be regarded as composed of lines AB, ab parallel to one another, and consisting of material particles of the same size and density. Now, by Art. 155. the centre of inertia of AB is F, and the centre of inertia of ab is c; and in the same way it may be shewn that the centre of inertia, of every line of which the surface is composed, lies in the line Ff. But Ff may be considered as composed of a number of material particles of uniform density, each being equal in weight to the particles in the line AB, therefore by Art. 165. its centre of inertia will be in φ, its middle point. Fig. 7.

Prop. VI.

165. To find the centre of inertia of a triangle.

Let ABC be a triangle of uniform density, and let AB, BC be bisected in the points E, D. Join CE, AD, and the point of intersection F shall be the centre of inertia of the triangle ABC. The triangle may be considered as composed of a number of parallel lines of material particles BC, bc, $\beta\kappa$; but in the similar triangles ADC, Aec; $AD : DC = Ae : ec$, and in the triangles ADC, ADB, Aeb; $BD : DA = be : eA$; hence by composition $BD : DC = be : ec$; but BD and DC are equal; therefore, $be = ec$; and the line bc, supposed to consist of material particles, will be in equilibrio about e. In the same way it may be shewn that every other line $\beta\kappa$ will be in equilibrio about a point situated in the line AD; consequently the centre of gravity is in that line. For the same reason it follows, that the centre of gravity is in the line CE, that is, it will be in F, the point of intersection of these two lines. In order to determine the relation between FA and FD, join ED; then, since $BE = EA$, and $BD = DC$, $BE : EA = BD : DC$, and consequently, (Geometry, Sect. IV. Theor. 18.) ED is parallel to AC, and the triangles BED, BAC similar. We have, therefore, $CA : CB = DE : DB$, and by alternation $CA : DE = CB : DB$, that is, $CA : DE = 2 : 1$. In the similar triangles CFA, DFE, $AF : AC = DF : DE$, and by alternation $AF : DF = AC : DE$, that is, $AF : DF = 2 : 1$, or $AF = \frac{2}{3}AD$. Fig. 2.

166. Cor. 1. By Geometry, Theor. 16. Sect. IV. we have

$$AB^2 + AC^2 = 2BD^2 + 2AB^2 (= \tfrac{1}{2}BC^2 + \tfrac{9}{2}\overline{AF^2}$$
$$AB^2 + BC^2 = 2CC^2 + 2BG^2 = \tfrac{1}{2}\overline{AC^2} + \tfrac{9}{2}\overline{CF^2}$$
$$AC^2 + BC^2 = 2AE^2 + 2EC^2 = \tfrac{1}{2}AB^2 + \tfrac{9}{2}\overline{BF^2}.$$

By

Theory.

By adding these three equations, and removing the fractions, we have $AB^2+BC^2+AC^2=3\,AF^2+3\,CF^2+3BF^2$, or in any plane triangle, the sum of the squares of the three sides is equal to thrice the sum of the squares of the distances of the centre of gravity from each of the angular points.

167. Cor. 2. By resolving the three quadratic equations in the preceding corollary, we obtain $AF=\frac{1}{3}\sqrt{2AB^2+2AC^2-BC^2}$; $CF=\frac{1}{3}\sqrt{2BA^2+2BC^2-AC^2}$; and $BF=\frac{1}{3}\sqrt{2BC^2+2AC^2-AB^2}$, formulæ which express the distances of the centre of gravity from each of the angular points.

Prop. VII.

168. To find the centre of inertia of a trapezium or any rectilineal figure.

Fig. 9. Let ABCDE be the trapezium, and let it be divided into the triangles ABC, ACE, ECD by the lines AC, EC. By the last proposition find m, n, o, the centres of gravity of the triangles, and take the point F in the line $m\,n$, so that $F\,n : F\,m$ = triangle ABC : triangle ACE, then F will be the centre of gravity of these triangles. Join $F\,o$, and find a point f, so that $f\,o : F\,f$ = triangle ABC + triangle ACE : triangle CED, then all the triangles will be in equilibrio about f, that is, f is the centre of gravity of the rectilineal figure ABCDE. The same method may be employed in finding the centre of gravity of a trapezium, whatever be the number of its sides.

Prop. VIII.

169. To find the centre of inertia of a pyramid with a polygonal base.

Fig. 10. Let the pyramid be triangular, as ABCD, fig. 10. Bisect BD in F, and join CF and FA. Make $Ff=\frac{1}{3}$ of FC, and $F\,\varphi=\frac{1}{3}$ of FA, and draw $f\varphi$. It is evident, from Art 159. that f is the centre of gravity of the triangular base BCD, and that the line AF, which joins the vertex and the point f, will pass through the centre of gravity of all the triangular laminæ or sections of the pyramid parallel to its base ABC; for, by taking any section $b\;c\;d$, and joining $c\;m$, it may be easily shewn, that $b\;m=m\;d$, and $m\;n=\frac{1}{3}m\;c$, so that n is the centre of gravity of the section $b\;c\;d$. It follows, therefore, that $A\,f$ will pass through the centre of gravity of the pyramid. In the same way it may be shewn, by considering ABD as the base, and D the vertex, and making $F\varphi=\frac{1}{3}FA$, that the centre of gravity lies in the line φ C. But, as the lines $A\,f$, φ C lie in the plane of the triangle AFC, they must intersect each other; and therefore the point of intersection H will be the centre of inertia of the triangular pyramid. Now, since $Ff=\frac{1}{3}FC$, and $F\,\varphi=\frac{1}{3}FA$, we have $F\varphi : FA=Ff : FC$, therefore (Geometry, Theor. 8. Sect. IV.) φf is parallel to AC. The triangle φfH will consequently be similar to AHC, and $H\,\varphi : HC=Hf : HA=f\varphi : AC=1:3$; therefore $H\,\varphi=\frac{1}{3}HC=\frac{1}{4}\varphi\,C$, and $fH=\frac{1}{3}AH=\frac{1}{4}Af$.

170. When the pyramid has a polygonal base, it may be conceived to be formed of a number of triangular pyramids, whose centres of inertia will be in one plane parallel to the base. Their common centre of gravity will therefore be in the same plane, and in the line drawn from the vertex to the centre of gravity of all the triangles which compose the base; the distance of the centre of gravity, therefore, from the vertex, will be equal to three-fourths of the altitude of the pyramid.

171. Cor. 1. Hence it is obvious, that the centre of gravity of a right cone is a point in its axis, whose distance from the vertex is equal to three-fourths of the length of the axis; for as this may be demonstrated of a pyramid whose base is a polygon, with an infinite number of sides, it must hold also of a right cone which may be considered as a pyramid of this description.

172. Cor. 2. By proceeding as in Art. 160. it will be found, that in a triangular pyramid, the distance of any of the vertices from its centre of inertia, is equal to one-fourth of the square root of the difference of thrice the sum of the squares of the three edges which meet at that vertex, and the sum of the squares of the other three edges;—and likewise, that ths sum of the squares of the distances of the centre of inertia from the vertices of any triangular pyramid, is eqnal to one-fourth of the sum of the squares of the six edges of the pyramids. A demonstration of these theorems may be seen in Gregory's Mechanics, vol. i. p. 59, 60.

173. In order to shew the application of the doctrine of fluxions to the determination of the centre of inertia of curve lines, areas, solids, and the surfaces of solids, let ABC be any curve line whose axis is BR. Fig. 11.
Then, since the axis bisects all the ordinates DG, AC, each of the ordinates, considered as composed of material particles, will be in equilibrio about the points of bisection E, R; and therefore the centre of inertia of the body will lie in the axis. But, if we consider the body as composed of a number of small weights $D\,d\,g\,G$, we shall find its centre of inertia by multiplying each weight by its distance from any line $m\;n$ parallel to the ordinates, and dividing the sum of all these products by the sum of all the particles, Art. 158. Thus, let x denote the distance EB, then its fluxion $\dot{x}$ will be the breadth of the element or small weight $D\,d\,g\,G$, and $\dot{x}\times DG$ will represent the weight, and the fluent of this quantity will be the sum of all the weights. Again, if we multiply the weight $\dot{x}\times DG$ by $x=EB$ its distance from the point B, we shall have the momentum of that weight $=x\times\dot{x}\times DG$, and the fluent of this quantity will express the sum of the momenta of all the weights into which the body is divided. But, by Art. 158. the distance of the centre of gravity from a given point B is equal to the sum of all the momenta divided by the sum of all the weights or bodies, that is, if F be the centre of gravity of the body ABC, we have $FB=\frac{\text{fluent of } x\times\dot{x}\,DG}{\text{fluent of } \dot{x}\times DG}$, or calling y the ordinate DE, we have $DG=2y$, and $FB=\frac{\text{fluent of } x\,2y\dot{x}}{\text{fluent of } 2y\dot{x}}$, or $FB=\frac{\text{fluent of } xy\dot{x}}{\text{fluent } y\dot{x}}$, in the case of areas.

174. In the case of solids generated by rotation, the element or small weight $F\,\dot{x}\times DG$ will be a circular section,

Theory.

section, whose diameter is $2\,DE=2\,y$, and since the area of a circle is equal to its circumference multiplied by its diameter, we have (making $\pi=3.1416$) $2\pi y^2 \dot{x}$, $=$the circular section whose diameter is DG; and since $x \times 2\pi y^2 \dot{x}$, or $2\pi x y^2 \dot{x}$, will represent the momentum of the weight, we shall have $FB=\frac{\text{fluent of } 2\pi x y^2 \dot{x}}{\text{fluent of } 2\pi y^2 \dot{x}}$, and dividing by $2\pi y$, we have $FB=\frac{\text{fluent of } y x \dot{x}}{\text{fluent of } y \dot{x}}$.

175. In finding the centre of inertia of the surfaces of solids, the elements or small weights are the circumferences of circles, whose radii are the ordinates of the curve by whose revolution the solid is generated. Now, the surface of the solid may be conceived to be generated by the circumference of a circle increasing gradually from B towards A and C; making z therefore equal to BD, its fluxion $\dot{z}$ multiplied into the periphery of the circle whose diameter is DG, that is, $2\pi y \dot{z}$, will express the elementary surface or small weight whose diameter is DG. Then, since $x \times 2\pi y \dot{z}$, or $2\pi x y \dot{z}$, will be the momentum of the elementary weight, we shall have $FB=\frac{\text{fluent of } 2\pi x y \dot{z}}{\text{fluent of } 2\pi y \dot{z}}$, and dividing by 2π we obtain $FB=\frac{\text{fluent of } x y \dot{z}}{\text{fluent of } y \dot{z}}$,

176. If the body, whose centre of inertia is to be found, be a curve line, as GBD, then it is manifest that the small weights will be expressed by the fluxion of

Fig. 11. GBD, that is, by $2\dot{z}$, since $GBD=2\,BD=2z$; consequently their momenta will be $2x\dot{z}$, and we shall have $FB=\frac{\text{fluent } 2x\dot{z}}{\text{fluent } 2\dot{z}}=\frac{\text{fluent } x\dot{z}}{\text{fluent } \dot{z}}=\frac{\text{fluent } x\dot{z}}{z}$,

Prop. IX.

177. To find the centre of inertia of a circular segment.

Fig. 12. Let $AE=x$, $FC=y$, and AD the radius of the circle $=$ R, consequently $ME=2\,R-EA$. Then, since by the property of the circle (Geometry, Theor. 28. Sect. IV.) $ME \times EA=BE^2$, we have, by substitution, $BE^2=2R \times EA-EA \times EA$, or $y^2=2Rx-x^2$; hence $y=\sqrt{2Rx-x^2}$. Now, by Art. 174. we have the distance of the centre of gravity from A, that is, $AG=\frac{\text{fluent } x y \dot{z}}{\text{fluent } y \dot{x}}$; but the fluent of $y\dot{x}$ or the sum of all the weights, is equal to the area of half the segment ABEC; therefore $AG=\frac{\text{fluent } x y \dot{x}}{\frac{1}{2}ABEC}$. Then, by substituting instead of y, in this equation, the value of it deduced from the property of the circle, we have $AG=\frac{\text{fluent of } x \dot{x}\sqrt{2Rx-x^2}}{ABEC}$; or, in order to find GD the distance of the centre of gravity from the centre, we must substitute instead of x (without the vinculum) its value $R-x$, and we have $GD=\text{fluent } \frac{(R-x)\dot{x}\sqrt{(2Rx-x^2)}}{\frac{1}{2}ABEC}$. Now, in order to find the fluxion of the numerator of the preceding fraction, assume $z=2Rx-x^2$, and $z^{\frac{1}{2}}=\sqrt{2Rx-x^2}$, and by taking the fluxion, we have $\dot{z}=2R\dot{x}-2x\dot{x}=\overline{2R-2x}\times\dot{x}$; but this quantity is double of the first term of the numerator, therefore $\frac{\dot{z}}{2}=\overline{R-x}\times\dot{x}$. By substituting these values in the fractional formula, we obtain $GD=$fluent $\frac{z^{\frac{1}{2}}}{2}\times\frac{1}{2}\dot{z}=\frac{z^{\frac{3}{2}}}{3}=\frac{\sqrt{2Rx-xx}|^{3}}{3}$; but since $y=\overline{2Rx-xx}|^{\frac{1}{2}}$ we have, by raising both sides to the third power, $y^3=\overline{2Rx-xx}|^{\frac{3}{2}}$; therefore $GD=\frac{\frac{1}{3}y^3}{\frac{1}{2}ABEC}=\frac{\frac{1}{24}\times 8y^3}{\frac{1}{2}ABEC}=\frac{\frac{1}{12}(2y)^3}{ABEC}$, that is, the distance of the centre of gravity of a circular segment from the centre of the circle, is equal to the twelfth part of the cube of twice the ordinate, (or the chord of the segment) divided by the area of the segment.

178. Cor. When the segment becomes a semicircle we have $2y=2r$; and therefore $=GD=\frac{\frac{1}{12}(2r)^3}{ABEC}=\frac{(2r)^3}{12\,ABEC}=\frac{8\times r^3}{12\,ABEC}=\frac{r^3}{1\frac{1}{2}ABEC}$, that is, the distance of the centre of gravity of a semicircle from the centre of the semicircle, is equal to the cube of the radius, divided by one and a half times the area of the segment.

Prop. X.

179. To find the centre of inertia of the sector of a circle.

Let ABDC be the sector of the circle. By Art. 157. find m the centre of inertia of the triangle BCD, and by the last proposition find G the centre of inertia of the segment; then take a point n so situated between G and m, that $ABEC : BCB=m\,n : G\,n$, then the point n will be the centre of gravity of the sector.— By proceeding in this way, it will be found that D n, or the distance of the centre of gravity of the sector from the centre of the circle, is a fourth proportional to the semiarc, to the semichord, and to two-thirds of the radius.

Prop. XI.

180. To find the centre of inertia of a plane surface bounded by a parabola whose equation is $y=a\,x^n$.

Since $y=a\,x^n$, multiply both terms by $x\dot{x}$, and $\dot{x}$ separately, and we have $yx\dot{x}=ax^{n+1}\dot{x}$, and $y\dot{x}=ax^n\dot{x}$. But, by Art. 174. we have $FB=\frac{\text{fluent of } x y \dot{x}}{\text{fluent } y \dot{x}}$, therefore, by substituting the preceding values of $xy\dot{x}$ and $y\dot{x}$ in the formula, we obtain $FB=\frac{\text{fluent of } a\,x^{n+1}\dot{x}}{\text{fluent of } a\,x^n\,\dot{x}}$, and

Theory. and by taking the fluents it becomes

$$FB=\frac{\dfrac{a x^{n+2}}{n+2}}{\dfrac{a x^{n+1}}{n+1}}=\frac{n+1}{n+2}\times x.$$

If n, therefore, be equal to $\frac{1}{2}$, then $y=a x^{\frac{1}{2}}$, and, squaring both sides, $y^2=a^2 x$, which is the equation of the common or Apollonian parabola. Hence, $FB=\frac{3}{5}x$, that is, the distance of the centre of gravity from the vertex is $\frac{3}{5}$ths of the axis.

When n is equal to 1, then $y=ax$, and the parabola degenerates into a triangle, in which case $FB=\frac{2}{3}x$, as in Art. 165.

Prop. XII.

181. To find the centre of inertia of a solid, generated by the revolution of the preceding curve round its axis.

Since $y=a x^n$, square both sides, and we have $y^2=a^2x^{2n}$; then multiply both sides by $x\dot{x}$, and $\dot{x}$ separately, we obtain $y^2x\dot{x}=a^2x^{2n+1}\dot{x}$, and $y^2\dot{x}=a^2x^{2n}\dot{x}$. But, by Art. 174. we have $FB=\frac{\text{fluent of } y^2x\dot{x}}{\text{fluent of } y^2\dot{x}}$; therefore, by substituting the preceding values of $y^2x\dot{x}$, and $y^2\dot{x}$ in that formula, we obtain $FB=\frac{\text{fluent of } a^2x^{2n+1}\dot{x}}{\text{fluent of } a^2x^{2n}\dot{x}}$, and by taking the fluents we shall have

$$FB=\frac{\dfrac{a^2x^{2n+2}}{2n+2}}{\dfrac{a^2x^{2n+1}}{2n+1}}=\frac{2n+1}{2n+2}\times x.$$

When $n=\frac{1}{2}$, the solid becomes a common paraboloid, and we obtain $FB=\frac{2}{3}x$.

When $n=1$, the solid becomes a cone, and $FB=\frac{3}{4}x$, as in Art. 171.

Prop. XIII.

182. To find the centre of gravity of a spherical surface or zone, comprehended between two parallel planes, or of the spherical surface of any spherical segment.

Fig. 12. Let BMNC be a section of the spherical surface comprehended between the planes BC, MN, and let $EP=x$, $EC=y$, $DC=R$, and $z=$ the arc CN. Suppose the abscissa EP to increase by the small quantity Eo, draw $o\,r$ parallel to EC, Cs parallel to Eo, and Cr perpendicular to DC; then it is evident, that in the similar triangles CDE, Csr, EC : DC=Cs : Cr, that is, $y : R=$ Cs : Cr; but Cr is the fluxion of the arc NC, and Cs the fluxion of the abscissa PE; therefore $y : R=\dot{x} : \dot{z}$, and $\dot{z}y=R\dot{x}$, and $\dot{z}=\frac{R\dot{x}}{y}$. Now, by Art. 175. $FB=\frac{\text{fluent of } xy\dot{z}}{\text{fluent of } xy\dot{z}}$, therefore, by substituting the preceding value of $\dot{z}$ in this formula, we obtain $FB=\frac{\text{fluent of } Rx\dot{x}}{\text{fluent of } R\dot{x}}$, for Theory.

$$\frac{\dfrac{Rx\dot{x}\dot{z}}{y}}{\dfrac{R\dot{x}\dot{z}}{y}}=\frac{Ryx\dot{x}\dot{z}}{Ry\dot{x}\dot{z}}\text{ (and dividing by } y\dot{z})=\frac{Rx\dot{x}}{R\dot{x}}.$$

By taking the fluents we obtain $FB=\frac{1}{2}\frac{Rx^2}{Rx}=\frac{1}{2}x$, a fluent which requires no correction, as the other quantities vanish at the same time with x.

183. When DP is equal to DC, the solid becomes a spherical segment, and EA becomes the altitude of the segment, so that universally the centre of gravity of the spherical surface of a spherical segment is in the middle of the line which is the altitude of the segment, or in the middle of the line which joins the centres of the two circles that bound the spherical segment.

184. When the spherical segment is a hemispheroid, the centre of gravity of its hemispherical surface is obviously at the distance of one-half the radius from its centre.

Prop. XIV.

185. To find the centre of gravity of a circular arc.

Let BAC be the circular arc, it is required to find its centre of inertia, or the distance of the centre of inertia of the half arc AC from the diameter HG; for it is evident, that the line which joins the centres of gravity of each of the semiarcs AB, AC must be parallel to HG, and therefore the distance of their common centre of gravity, which must be in that line, from the line HG, will be equal to the distance of the centre of gravity of the semiarc from the same line. Make $PC=DE=x$; $EC=y$; $DC=DA=R$, and $AC=z$, then it may be shewn, as in the last proposition, that $y : R=\dot{x} : \dot{z}$; hence $\dot{z}y=R\dot{x}$. But, by Art. 176. Fig. 13.

we have $FB=\frac{\text{fluent of } y\dot{z}}{z}$, y being in this case equal to x in the formula in Art. 176. and substituting the preceding value of $y\dot{z}$, it becomes $FB=\frac{\text{fluent of } R\dot{x}}{z}$, and, taking the fluent, we have $FB=\frac{Rx}{z}$, which requires no correction, as the fluent of $y\dot{z}$ vanishes at the same time with x. Calling d, therefore, the distance of the centre of inertia of the arc BAC from the centre D, we have $d=\frac{Rx}{z}$, and $dz=Rx$; hence $z : x=R : d$, or $2Z : 2x=R : d$, that is, the distance of the centre of inertia of a circular arc from the centre of the circle is a fourth proportional to the arc, the chord of the arc, and radius.

186. When the arc BAC becomes a semicircle, PC or x is equal to DG or radius, so that we have $2z : 2R=R : d$, or $4Z : 4R=R : d$; but $4z$ is equal to the whole circumference of the circle, and $4R$ is

Theory.

is equal to twice the diameter; therefore, 3.141593 : 2 $=$R : d; hence $d=\frac{2\text{R}}{3.141593}=.63662$ R.

187. When y is equal to 2R, or when the arc ABC becomes equal to the whole circumference of the circle, x vanishes, and is $=0$, and therefore $\frac{\text{R}x}{z}=0$, which shews, that the centre of inertia coincides with the centre of the circle.

Scholium I.

188. From the specimens which the preceding propositions contain of the application of the formulæ in Articles 173, 174, 175, 176, the reader will find no difficulty in determining the centre of inertia of other surfaces and solids, when he is acquainted with the equation of the curves by which the surfaces are bounded, and by whose revolution the solids are generated.

A knowledge of the nature of these curves, however, is not absolutely necessary for the determination of the centres of inertia of surfaces and solids. A method of finding the centre of gravity, without employing the equation of the bounding curves, was discovered by our countryman, Mr Thomas Simson*. It was afterwards more fully illustrated by Mr Chapman, in his work on the Construction of Ships; by M. Leveque, in his translation of Don George Juan's Treatise on the Construction and Management of Vessels; and by M. Prony, in his *Architecture Hydraulique*, tom. i. p. 93. to which we must refer such readers as wish to prosecute the subject.

* *Mathematical Dissertations*, p. 109.

Scholium II.

Position of the centre of inertia in bodies of various forms.

189. As it is frequently of great use to know the position of the centre of inertia in bodies of all forms, we shall collect all the leading results which might have been obtained, by the method given in the preceding propositions.

1. The centre of inertia of a straight line is in its middle point.

2. The centre of inertia of a parallelogram is in the intersection of its diagonals.

3. The centre of inertia of a triangle is distant from its vertex two-thirds of a line drawn from the vertex to the middle of the opposite side.

4. The centre of inertia of a circle, and of a regular polygon, coincides with the centres of these figures.

5. The centre of inertia of a parallelopiped is in the intersection of the diagonals joining its opposite angles.

6. The centre of inertia of a pyramid is distant from its vertex three-fourths of the axis.

7. The centre of inertia of a right cone is in a point in its axis whose distance from the vertex is three-fourths of the axis.

8. In the segment of a circle, the centre of inertia is distant from the centre of the circle a twelfth part of the cube of the chord of the segment divided by the area of the segment, or $d=\frac{\frac{1}{2}\text{C}^3}{\text{A}}$, where $d=$ the distance of the centre of inertia from the centre of the circle, C $=$ the chord of the segment, and A its axis.

9. In the sector of a circle, the centre of inertia is distant from the centre of the circle, by a quantity which is a fourth proportional to the semiarc, the semichord, and two-thirds of the radius.

10. In a spherical surface or zone, comprehended between two planes, the centre of inertia is in the middle of the line which joins the centres of the two circular planes by which it is bounded. When one of the circular planes vanishes, the spherical zone becomes the spherical surface of a spherical segment; therefore,

11. In a spherical surface of a spherical segment, the centre of inertia is in the middle of its altitude or versed sine; consequently,

12. The centre of inertia of the surface of a complete sphere coincides with the centre of the sphere.

13. In a spherical segment, the centre of inertia is distant from the vertex by a quantity equal to $\frac{4a-3x}{6a-4x}\times x$, where a is the diameter of the sphere, and x the altitude or versed sine of the segment. Hence,

14. The centre of inertia of a hemisphere is distant from its vertex by a quantity equal to five-eighths of the radius, or it is three-eighths of the radius distant from the hemisphere; and,

15. The centre of inertia of a complete sphere coincides with the centre of the sphere.

16. In a circular arc the centre of inertia is distant from its centre by a quantity equal to $\frac{\text{R}x}{z}$, where R is the radius, x the semichord, and z the semiarc. Hence,

17. In a semicircular arc the centre of inertia is distant from its centre .63662 R, and,

18. The centre of inertia of the circumference of a circle coincides with the centre of a circle.

19. In a circular sector the centre of inertia is distant from the centre of the circle $\frac{2c\text{R}}{3a}$, where R is the radius, a the arc, and c its chord.

20. In a spherical sector, composed of a cone and a spherical segment, the centre of inertia is distant from the vertex of the segment by a quantity equal to $\frac{2\text{R}+3x}{8}$, where R is radius, and x the altitude or versed sine of the segment.

21. In an ellipsis the centre of inertia coincides with the centre of the figure.

22. The centre of inertia of an oblate and prolate spheroid, solids generated by the revolution of an ellipse round its lesser and its greater axis respectively, coincides with the centres of the figures.

23. In the segment of an oblate spheroid the centre of inertia is distant from its vertex by a quantity equal to $\frac{4m-3x}{6m-4x}\times x$, where m is the lesser axis, or axis of rotation, and x the altitude of the segment. Hence,

24. In a hemispheroid the centre of inertia is distant from its vertex five-eighths of the radius.

25. The centre of inertia of the segment of a prolate spheroid

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Theory.

spheroid is distant from its vertex by a quantity equal to $\frac{4n-3x}{6m-4x} \times x$, where n is the greater axis, or axis of rotation.

26. In the common or Apollonian parabola, the distance of the centre of inertia from its vertex is three-fifths of the axis.

27. In the cubical parabola the distance of the centre of inertia from its vertex is four-sevenths of the axis, in the biquadratic parabola five-ninths of the axis, and in the sursolid parabola six-elevenths of the axis.

28. In the common semiparabola, the distance of its centre of gravity from the centre of gravity of the whole parabola, in the direction of the ordinate passing through that centre, is $\frac{1}{8}$ of the greatest ordinate.

29. In the common paraboloid, the distance of the centre of inertia from its axis, is equal to $\frac{2}{3}$ of the axis.

30. In the common hyperboloid, the distance of the centre of inertia from the vertex is equal $\frac{4a+3x}{6a+4x} \times x$, where a is the transverse axis of the generating hyperbola, and x the altitude of the solid.

31. In the frustum of a paraboloid, the distance of the centre of inertia from the centre of the smallest circular end is $\frac{2R^2+r^2}{R^2+r^2} \times \frac{h}{4}$, where h is the distance between the centres of the circles which contain the paraboloidal frustum, R the radius of the greater circle, and r the radius of the lesser circle.

32. In a conic frustum or truncated cone, the distance of the centre of inertia from the centre of the smallest circular end is $\frac{3R^2+2Rr+r^2}{R^2+Rr+r^2} \times \frac{h}{4}$ which represents the distance between the centres of the circles which contain the frustum, and R, r the radii of the circles.

33. The same formula is applicable to any regular pyramid, R and r representing the sides of the two polygons by which it is contained.

Prop. XIV.

190. If a quantity of motion be communicated to a system of bodies, the centre of gravity of the system will move in the same direction, and with the same velocity, as if all the bodies were collected in that centre, and received the same quantity of motion in the same direction.

Fig. 14. Let A, B, C be the bodies which compose the system, and let F be the centre of gravity of the bodies B, C, and f the centre of gravity of the whole system, as determined by Art. 155. Then if the body A receives such a momentum as to make it move to a in a second, join F a, and take a point φ so that F φ : φ a= F f : f a, φ will now be the centre of gravity of the system, $f\varphi$ the path of that centre will be parallel to A a, and $f\varphi$ will be to A a as B is to A+B+C. Let the same quantity of motion be now communicated to B, so as to make it describe the space B b, in a second; and having drawn φ G parallel to B b, take a point G, so that φ G : B b=B : A+B+C, and G will be the centre of gravity of the bodies after B has moved to b. In the same way it may be found, that H will be the common centre of gravity of the bodies after the same quantity of motion has been communicated to C in the direction C c. Now if the quantity of motion which was communicated to A, B, C separately had been communicated to them at the same instant, they would have been found at the end of a second in the points a, b, c, and their centre of gravity would have been the point H. Let us now suppose the three bodies collected in their common centre of gravity f, the body at F will be equal to A+B+C, and if the same quantity of motion which made A move to a in a second be communicated to the body at f and in the same direction, it will be found somewhere in the line $f\varphi$ at the end of a second. But as the quantity of motion is equal to the product of the velocity of the body multiplied by its quantity of matter, the velocities are inversely as the quantities of matter, and consequently the velocity of the body at f is to A's velocity as A is to A+B+C, that is, as $f\varphi$ is to A a; therefore A a and $f\varphi$ are described by A and by the body at f in equal times, and the body at f will be found at φ at the end of a second. In the same way it may be shewn, that the body at f will be found at G if it receives the same momentum that was given to B, and in the same direction, and that it will be found at H after it has received the momentum that was communicated to C, consequently if it received all these momenta at the same instant, it would have described f H in a second. Q. E. D.

191. Cor. 1. If the bodies of a system move uniformly in right lines, their common centre of gravity will either be at rest, or move uniformly in a right line. For if the momenta communicated to the bodies A, B, C were communicated to a body at f=A+B+C, it will either remain at rest or move uniformly in a straight line. See *Newton's Principia*, I. Sect. III. Cor. 1.

192. Cor. 2. The centre of gravity of any system is not affected by the mutual action of the bodies which compose it. For let B and C be two bodies whose common centre of gravity is F; and let the points β, $\varkappa$, be taken, so that B β : C $\varkappa$=C : B, the spaces B β, C $\varkappa$ will represent the mutual action of the bodies B, C, that is, B β will represent the action of C upon B, or the motion which is the result of that action, and C $\varkappa$ the action of B upon C, or the motion which results from it. Then, since F is the common centre of gravity of B and C, we have (Art. 155.) B : C=FC : FB, but B : C=C $\varkappa$: B β, therefore FC : FB=C $\varkappa$: B β; but C $\varkappa$ is a magnitude taken from FC, and B β is a magnitude taken from FB, consequently (Playfair's Euclid, Book V. Prop. 19.) the remainder $\varkappa$ F : β F =FC : FB, that is, $\varkappa$ F : β F=B : C, that is, (Art. 155.) the point F continues to be the centre of gravity notwithstanding the action of the bodies B, C. If the system is composed of several bodies, the same thing may be proved of every two of the bodies, and consequently of the whole system. See *D'Alembert's Dynamique*, Art. 76. and *Newton's Principia*, I. Sect. III. Cor. 4. Fig. 14.

Prop. XV.

193. If a body is placed upon a horizontal plane, or suspended by two threads, it cannot be in equilibrio

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equilibrio unless a perpendicular drawn from the centre of gravity to the horizontal plane, or to a horizontal line passing through the two threads, fall within the base of the body, or upon that part of the horizontal line which lies between the threads.

Fig. 15. 194. Let ABCD be a body placed in the horizontal plane CD, G its centre of gravity, and GE a perpendicular drawn to the horizontal line DE. Then the whole matter of the body ABCD may be conceived as united in its centre of gravity G, and as its tendency downwards is in the vertical line GE, it can descend only by turning round the point C as a centre. Here then we have a body G placed at the end of a lever GC whose fulcrum is C, and its power to turn round C is represented by the quantity of matter in G multiplied by the perpendicular CE, let fall from the fulcrum upon its line of direction; and as there is no force to counterbalance this, the body G, and consequently the body ABCD, will fall by turning round C. When the vertical line GE coincides with GC, EC vanishes, and the weight of the body concentrated at G has no power to turn the lever round C, but is supported upon the fulcrum C. When the vertical line GE, (by some writers called the *line of direction*), falls within the base CD, it is obvious that the weight at G has no influence in producing a motion round C or D, but is employed in pressing the body upon the horizontal plane ED.

Fig. 16. 195. 2. Let the body ACBD be suspended at the points f, φ by the threads hf, $h'\varphi$, and let G be the centre of gravity of the body. Join Gφ, Gf, draw $f\varphi$ parallel to the horizon, and through G draw $n\ o$ parallel to $f\varphi$. Continue hf, $h'\varphi$ to o and n, and draw Gi perpendicular to $f\varphi$, the body AB cannot be in equilibrio unless the point i falls upon the horizontal line $f\varphi$ which passes through the threads. It is obvious that the centre of gravity can never change its distance from the fixed points of suspension f, φ; if therefore the body is not in equilibrio, its centre of gravity must descend either towards m or n; let it descend towards m till it rests at the point γ, then $\gamma f = f$G; but $\gamma\varphi$ is greater than Gφ (Euclid, Book I. Prop. 7.) which is absurd, therefore the point G cannot descend, that is, the body is in equilibrio. It may be shewn in the same way, that it will be in equilibrio when G is any where between n and o, that is, when the perpendicular let fall from G cuts the horizontal line $f\varphi$ that lies between the threads. If the body be suspended by the two threads HE, hf, so that the perpendicular Gi falls without the line fF, the body is not in equilibrio, for the centre of gravity G acting at the end of the lever GF tends to turn round F with a power eqal to G$\times$Gm, it will therefore descend, and as its distance from f cannot change, the point f will rise, and the thread fh will be relaxed. When G arrives at m the perpendicular Gm vanishes, and G has no power to turn round F. The body AB therefore cannot be in equilibrio till the perpendicular Gi falls within fF, which it does as soon as it arrives at m.

196. Cor. 1. If a body is placed upon an inclined plane, supposed without friction, it will slide down the plane when the line of direction falls within its base, and will roll down when this line falls without the base. This is the reason why a sphere or cylinder rolls down an inclined plane; for as they touch the plane only in one point or line, the line of direction must always fall without the base. Theory.

197. Cor. 2. The higher the centre of gravity of a body is, the more easily will it be overturned. For if ABCD be the body whose centre of gravity is F, and if any force be employed to move it round C as a fulcrum, the power with which it will resist this force is inversely as FC; then, if the centre of gravity is raised to f, fC will be greater than FC, and the power with which it resists being overturned is diminished, that is, the body is the more easily overturned the higher that its centre of gravity is placed. Fig. 17.

198. Cor. 3. If a body be suspended by one thread, it will not be at rest unless its centre of gravity is in the direction of the thread produced, for when the two threads hf', $h'\varphi$ approach so near each other as to coincide with the single thread HE, the point i must in the case of an equilibrium fall upon F, and the lines Gi, GF must coincide with mF; but HF and mF are both perpendicular to the horizontal line $f\varphi$, therefore the centre of gravity G is in the direction of the the thread HF.

199. Cor. 4. If the bodies A, B, C, fig. 18. be suspended by any point F from the hook H, they will not be in equilibrio unless their common centre of gravity G is in the vertical line FG passing through the point of suspension; and in fig. 19. the bodies A, B connected by the bent rod AFB will not be in equilibrio unless their common centre of gravity G is in a vertical line passing through F, the point in which the system rests upon the plane CD. Fig. 18. Fig. 19.

Scholium.

200. We have seen in the preceding proposition and corollaries, the position which must be given to the centre of gravity in order to procure an equilibrium. It is evident, however, that though the bodies are necessarily at rest, yet they have different degrees of stability, depending on the position of the centre of gravity with regard to the centre of motion. Hence bodies are said to have a stable equilibrium when their centre of gravity cannot move without ascending, or when the path described by their centre of gravity has its concavity upwards;—a tottering equilibrium when the centre of gravity cannot move without descending, or when the path which it describes has its concavity downwards,—and a neutral equilibrium when the body will rest in any position. Thus in fig. 20. if the vessels A, B have their handles so placed that in the one the handle A is fixed above the centre of gravity g, and in the other the handle B is fixed below the centre of gravity g, then the equilibrium of A will be stable, and that of B tottering; for if A is held by the handle it will require a considerable force to make its centre of gravity describe the path $m\ n$, whereas the smallest force will destroy the equilibrium of B. The vessel A, too, has a constant tendency to recover its equilibrium, and always recovers it as soon as the disturbing force is removed, but the vessel B has no tendency to do this even when its equilibrium is affected in the smallest degree. For the same reason the elliptical body A, when resting on the extremity of its conjugate axis, has a stable equilibrium, but when resting on its transverse axis as at B, its equilibrium

Different kinds of equilibrium.

Fig. 20. Fig. 21.

heory. um is tottering. The equilibrium of a circle or sphere is always neutral, for when it is disturbed, the body has neither a tendency to fall nor to resume its former situation.—A flat body A supported by a sphere B will have its equilibrium stable when its centre of gravity is nearer the point of contact than the centre of the sphere is, and the equilibrium of C will be tottering when its centre of gravity is farther distant from the surface of the sphere D than the centre of the sphere is.

. 22.

Prop. XVI.

1. To find the centre of inertia mechanically.

chanical thod of ling the tre of vity.

201. If the body whose centre of inertia is to be found can be suspended by a thread, then when the body is in equilibrio, the centre of gravity will be somewhere in the line, prolonged if necessary, that is formed by the thread upon the surface of the body. Let a body be again suspended from another part of its surface, so that the direction of the thread may be nearly at right angles to its former direction, then as the centre of gravity must also be in the new direction of the thread prolonged, it will be in the point where these two lines intersect each other.

202. 2. If the body is of such a kind that it cannot be conveniently suspended, balance it upon two sharp points, and its centre of motion will be somewhere in the line which joins these points. Balance it a second time upon the sharp points, so that the line which joins the points may be nearly at right angles to the former line. The intersection of these two lines will be the centre of inertia of the body.

203. 3. If the body is so flexible that it can neither be suspended by a thread nor balance upon points, then let a thin board be balanced upon the points as before, and let the body be so placed upon this board when balanced, that the equilibrium may still continue; then, having found the centre of gravity of the board when loaded with the body, the centre of gravity of the body will be a point on its surface exactly opposite to that centre.

204. The preceding method, however, only gives us the centre of gravity when the body has no sensible thickness, for when it is of three dimensions, the centre of gravity must be somewhere between the two opposite surfaces.

205. *Definition.*—The centro-baryc method is the method of determining the areas of surfaces, and the contents of solids, by considering them as generated by motion, and by employing the laws of the centre of gravity.

Prop. XVII.

entro-ryc me-od of uldinus.

206. If any straight or curve line, or any plane surface bounded by straight or curve lines, revolve round an axis situated in the same plane with the lines or surfaces, the surface or solid thus generated will be respectively equal to a surface or solid whose base is equal to the given line or surface, and whose height is equal to the arc described by the centre of gravity of the generating line or surface.

g. 23. Let ABCD be the plane surface by whose revolution round the axis MPN is generated the solid a D, contained by the parallelograms ABCD, $a\,b\,c\,d$, and by the areas a AC c, b BD d, and a AB b, c CD d; let G be the centre of gravity of ABCD, then the solid a D shall be equal to a solid whose base is ABCD, and whose altitude is a line equal to G g, the space described by its centre of gravity G. It is evident from Art. 161. that the sum of the products of all the particles of the surface ABCD, multiplied by their respective distances from any given point P, is equal to the sum of all the particles multiplied by the distance of their common centre of gravity G from the same point P. Now every particle of the surface ABCD, during its revolution round the point P, will obviously describe the arch of a circle proportional to the distance of that particle from the point P, which is the centre of all the arches; therefore the sum of the product of all the particles multiplied by the arch described by each of them, will be equal to the sum of the particles multiplied by the arch which their common centre of gravity describes; that is, the solid a D will be equal to the area of the surface multiplied by the path of its centre of gravity. In order to have a clearer illustration of this reasoning, let P, p, π, &c. be the particles of the surface ABCD; D, d, δ their distance from the centre of rotation P, and A, a, α, the arches which they describe, while GP is the distance of the centre of gravity of the surface ABCD from the centre P, and G g the arch described by it. Then by Art. 161. $\overline{P\times D}+\overline{p\times d}+\overline{\pi\times\delta}=\overline{P+p+\pi}\times GP$, but $D:d:\delta:GP=A:a:\alpha:Gg$, therefore $\overline{P\times A}+\overline{p\times a}+\overline{\pi\times\alpha}=\overline{P+p+\pi}\times Gg$. But $\overline{P\times A}+\overline{p\times a}+\overline{\pi\times\alpha}$ &c. make up the whole solid a D, and $\overline{P+p+\pi}$, &c. make up the whole surface ABCD; therefore the solid a D is equal to the generating surface ABCD multiplied by the path of its centre of gravity. Q. E. D.

Theory.

207. Cor. 1. Let us suppose the circle BACO to be generated by the revolution of the line DA round the point D; then since the centre of gravity of the line DA is in its middle point G, the path of this centre will be a circumference whose radius is DG, or a line equal to half the circumference BONAB, therefore, by the theorem, the area of the circle BONB will be equal to the radius DA multiplied by the semicircumference, which coincides with the result obtained from the principles of geometry. See Playfair's Geometry, Supp. B. I. Prop. 5. In the same way, by means of the preceding theorem, we may readily determine the area of any surface, or the content of any solid that is generated by motion. Fig. 12.

Scholium.

208. The centro-baryc method, which is one of the finest inventions of geometry, was first noticed by Pappus in the preface to the seventh book of his mathematical collections; but it is to Father Guldinus that we are indebted for a more complete discussion of the subject. He published an account of his discovery partly in 1635, and partly in 1640, in his work entitled *De Centro Gravitatis*, lib. ii. cap. 8. prop. 3. and gave an indirect demonstration of the theorem, by showing the conformity of its results with those which were obtained by other means. Leibnitz demonstrated the theorem in the case of superficies generated by the revolution of curves, but concealed his demonstration (Act. Leips. 1695, p. 493.

Theory.

493. The theorem of Leibnitz, however, as well as that of Guldinus was demonstrated by Varignon in the Memoirs of the Academy for 1714, p. 78. Leibnitz observes that the method will still hold, even if the centre round which the revolution is performed be continually changed during the generating motion. For further information on this subject, the reader is referred to Dr Wallis's work, *De Calculo Centri Gravitatis*, Hutton's Mensuration, Prony's Architecture Hydraulique, vol. i. p. 88. and Gregory's Mechanics, vol. i. p. 64.

PROP. XVIII.

209. To show the use of the doctrine of the centre of gravity in the explanation of some mechanical phenomena.

On the motion of animals.

In the equilibrium and motion of animals we perceive many phenomena deducible from the properties of the centre of gravity. When we endeavour to rise from a chair, we naturally draw our feet inwards, and rest upon their extremities, in order to bring the centre of gravity directly below our feet, and we put the body into that position in which its equilibrium is tottering, a position which renders the smallest force capable of producing motion, or of overturning the body. In this situation, in order to prevent ourselves from falling backwards, we thrust forward the upper part of the body for the purpose of throwing the centre of gravity beyond our feet: and when the equilibrium is thus destroyed, we throw out one of our feet, and gradually raise the centre of gravity till the position of the body is erect.—When we walk, the body is thrown into the position of tottering equilibrium by resting it on one foot; this equilibrium is destroyed by pushing forward the centre of gravity, and the body again assumes the position of tottering equilibrium by resting it on the other foot. During this alternate process of creating and destroying a tottering equilibrium, the one foot is placed upon the ground, and the other is raised from it; but in running, which is performed in exactly the same way, both the feet are never on the ground at the same time: At every step there is a short interval, during which the runner does not touch the ground at all.

210. When we ascend an inclined plane the body is thrown farther forward than when we walk on a horizontal one, in order that the line of direction may fall without our feet; and in descending an inclined plane, the body is thrown backward, in order to prevent the line of direction from falling too suddenly without the base. In carrying a burden, the centre of gravity is brought nearer to the burden, so that the line of direction would fall without our feet if we did not naturally lean towards the side opposite to the burden, in order to keep the line of direction within our feet. When the burden is therefore carried on the back, we lean forward; when it is carried in the right arm, we lean towards the left; when it is carried in the left arm, we lean towards the right; and when it is carried before the body, we throw the head backwards.

211. When a horse walks, he first sets out one of his fore feet and one of his hind feet, suppose the right foot; then at the same instant he throws out his left fore foot and his left hind foot, so as to be supported only by the two right feet. His two right feet are then brought up at the same instant, and he is supported only by his two left feet. When a horse pulls at a load which he can scarcely overcome, he raises both his fore feet, his hind feet become the fulcrum of a lever, and the weight of the horse collected in his centre of gravity acts as a weight upon this lever, and enables him to surmount the obstacle. See Appendix to Ferguson's Lectures, vol. ii.).

Theory.

Method in which a rope-dancer keeps his equilibrium.

212. When a rope-dancer balances himself upon the fore part of one foot, he preserves his equilibrium in two ways, either by throwing one of his arms or his elevated foot, or his balancing pole, to the side opposite to that towards which he is beginning to fall, or by shifting the point of his foot, on which he rests, to the same side towards which he is apt to fall; for it amounts to the same thing whether he brings the centre of gravity directly above the point of support, or brings the point of support directly below the centre of gravity. For this purpose the convex form of the foot is of great use, for if it had been perfectly flat, the point of support could not have admitted of small variations in its position *.

* See Dr T Young's *Natural Philosophy*, vol. i. p. 64.

The construction of mail coaches erroneous.

213. We have already seen (Art. 197.) that any body is more easily overturned in proportion to the height of its centre of gravity. Hence it is a matter of great importance that the centre of gravity of all carriages should be placed as low as possible. This may often be effected by a judicious disposition of the load, of which the heaviest materials should always have the lowest place. The present construction of our mail and post coaches is therefore adverse to every principle of science, and the cause of many of those accidents in which the lives of individuals have been lost. The elevated position of the guard, the driver, and the outside passengers, and the two boots which contain the baggage, raises the centre of gravity of the loaded vehicle to a very great height, and renders it much more easily overturned than it would otherwise have been. When any accident of this kind is likely to happen, the passengers should bend as low as possible, and endeavour to throw themselves to the elevated side of the carriage.—In two wheeled carriages where the horse bears part of the load upon its back, the elevation of the centre of gravity renders the draught more difficult, by throwing a greater proportion of the load upon the horse's back when he is going down hill, and when he has the least occasion for it; and taking the load from the back of the horse when he is going up hill, and requires to be pressed to the ground.

Fig. 24.

214. A knowledge of the laws of the centre of gravity enables us to explain the experiment represented in fig. 24. where the vessel of water CG is suspended on a rod AB, passing below its handle, and resting on the end E of the beam DE. The extremity B of the rod AB is supported by another rod BF, which bears against the bottom of the vessel; so that the vessel and the two rods become, as it were, one body, which, by Art. 199. will be in equilibrio when their common centre of gravity C is in the same vertical line with the point of support E.

A loaded cylinder may be made to ascend an inclined plane by its own weight.

215. The cylinder G may be made to ascend the inclined plane ABC by putting a piece of lead or any heavy substance on one side of its axis, so that the centre of gravity may be moved from G towards g. Hence it

it is obvious, that the centre of gravity g will descend, and by its descent the body will rise towards A. The inclination of the plane, however, must be such, that before the motion commences, the angles formed by a vertical line drawn from g with a line drawn from G perpendicularly to AB, must be less than the angle of inclination ABC, or, which is the same thing, when the vertical line drawn from g does not cut the line which lies between the point of contact and the centre of the cylinder. When the vertical line, let fall from g, meets the perpendicular line drawn from G to the plane in the point of contact, the cylinder will be in equilibrio on the inclined plane.

ouble e may made to end an lined ne by own ght. . 26.

216. Upon the same principle, a double scalene cone may be made to ascend an inclined plane without being loaded with a weight. In fig. 26. let ABC be the section of a double inclined plane, AB, BC being sections of its surfaces perpendicular to the line in which the double scalene cone ADEFC moves. Then, since the centre of gravity of a cone is in the line joining the vertex and the centre of its base, and since the axis of a scalene cone is not perpendicular to its base, the line which joins the centres of both the cones, when in the position represented in the figure, will be above the line which joins the centres of their bases. If the circle, therefore, in fig. 27. represents the base of one of the cones, and C its centre, the line which joins the centres of gravity of the two cones will terminate in some point G at a distance from the centre, and therefore the double cone will ascend the plane upon the same principles, and under the same conditions, as those mentioned in the last paragraph.

. 27.

CHAP. V. *On the Motion of Bodies along inclined Planes and Curves, on the Curve of swiftest descent, and on the Oscillations of Pendulums.*

PROP. I.

Plate CCXXI. fig. 1.

217. When a body moves along an inclined plane, the force which accelerates or retards its motion, is to the whole force of gravity as the height of the plane is to its length, or as the sine of its inclination is to radius.

Let ABC be the inclined plane, A the place of the body, and let AB represent the whole force of gravity. The force AB is equivalent to the two forces AD, DB or AE, AD, of which AD is the force that accelerates the motion of the body down the plane, while AE is destroyed by the resistance or re-action of the plane. The part of the force of gravity, therefore, which makes the body arrive at C is represented by AD, while the whole force of gravity is represented by AB; but the triangle ABD is equiangular to ABC, and AD : AB=AB : AC, that is, the accelerating force which makes the body descend the inclined plane, is to the whole force of gravity as the height of the plane is to its length, or as the sine of the plane's inclination is to radius; for when AC is radius, AB becomes the sine of the angle ACB.

218. COR. 1. Since the force of gravity, which is uniform, has a given ratio to the accelerating force, the accelerating force is also uniform; consequently the laws of accelerated and retarded motions, as exhibited in the article DYNAMICS, are also true when the bodies move along inclined planes. If H, therefore, represent the height AB of the plane, L its length AC, g the force of gravity, and A the accelerating force, we shall have, by the proposition, L : H$=g$: A, hence, $A=g\times\frac{H}{L}$, or, since g : A=radius : sin, ACB, and A $=g\times$ sin. ACB. Now, from the principles of DYNAMICS, $s=\frac{1}{2}g\,t^2$, $v=g\,t=\sqrt{2\,g\,s}$, and $t=\frac{v}{g}=\sqrt{\frac{2s}{g}}$, where s is the space described, g the force of gravity, or $32\frac{1}{4}$ feet, v the velocity, and t the time. Making φ, therefore, equal to ACB, and substituting the value of A instead of g in the preceding equation, we shall have $s'=\text{sin.}\,\varphi\times\frac{1}{2}t'$; $v'=g\,\text{sin.}\,\varphi\,t=\sqrt{2gs'\text{sin.}\,\varphi}$, and $t=\frac{v'}{g.\,\text{sin.}\,\varphi}=\sqrt{\frac{2s'}{g.\,\text{sin.}\,\varphi}}$.

219. COR. 2. If one body begins to descend through the vertical AB at the same time that another body descends along the plane AC, when the one is at any point m, the position of the other will bo n, which is determined by drawing $m\,n$ perpendicular to AC. The forces by which the two bodies are actuated, are as AB to AD, that is, as A m to A n; but forces are measured by the spaces described in the same time; therefore, the spaces described in the same time, are as A m, A n, that is, as the length of the plane is to its height; for A m : A n=AC : AB; consequently, when the body that descends along the vertical line AB is at m, the other body will be at n.—Through the three points A, m, n describe the semicircle A m n; then, since A n m is a right angle, the centre of the semicircle will be in the line A m (Playfair's Euclid, Book iv. Prop. 5.); consequently, *if two bodies descend from the point A at the same time, the one through the diameter of a circle* A m, *and the other through any chord* A n, *they will arrive at the points* m n, *the extremities of the diameter and of the chord at the same instant.* It also follows from this corollary, that if from the point A there be drawn any number of lines making different angles with the diameter A m, and if bodies be let fall from A, so as to move along these lines, they will, at the end of any given time, be found in the circumferences of circles which touch one another in the point A. If the lines are not in the same plane, the bodies will be in the circumferences of spheres which touch each other in the point A.

220. COR. 3. If any number of bodies descend from the same point A along any number of inclined planes AC, AF, their velocities at the points C, F will be equal. By Cor. 1. the velocity of a body descending the plane AC, is $v=\sqrt{2\,g\,s\,\text{sin.}\,\varphi}$, and the velocity of a body falling in the vertical line AB is $v'=\sqrt{2\,g\,s'}$. But, since $v=v'$, we have $\sqrt{2\,g\,s\,\text{sin.}\,\varphi}=\sqrt{2\,g\,s'}$ or $2\,g\,s\,\text{sin.}\,\varphi=2\,g\,s'$, and dividing by $2\,g$; $s\,\text{sin.}\,\varphi=o$, consequently s : s'=sin. φ : 1, or AB : AC=sin. DAB : radius. Therefore, when $v=v'$, that is, when the velocities of the two bodies are equal, the spaces described are as sin. DAB : radius, which can only happen when BC is perpendicular to AB. In the same way it may be shewn that the velocity at F is equal to the velocity at C, therefore the velocity at C is equal to the velocity at F.

221. COR. 4. The time of descending along AC is to

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to the time of descending along AB, as AC is to AB. From the values of s, s' in Cor. 1. we obtain $t^2 : t'^2 = \frac{s}{\sin.\varphi} : s' = \frac{AC}{\sin.\varphi} : AB$. But $\frac{AB}{AC} = \sin.\varphi$; therefore, $t^2 : t'^2 = \frac{AC^2}{AB} : AB$, and taking equal multiples of these two last terms, that is, multiplying them by AB, we have $t^2 : t'^2 = AC^2 : AB^2$, or $t : t' = AC : AB$. Hence the times of descending along AF and AC, are as AF and AC.

222. Cor. 5. The velocities acquired by descending any planes AC, AF, are as the square roots of their altitudes AB. The velocity acquired by falling through AB is, by the principles of Dynamics, as the square root of AB; and as the velocities at F, C are equal to that at B, they will also be as the square root of AB.

Prop. II.

223. If a body descend from any point along a number of inclined planes to a horizontal line, its velocity, when it reaches the horizontal line, will be equal to that which it would have acquired by falling in a vertical direction from the given point to the horizontal line.

Fig 2. Let AB, BC, CD, be a number of planes differently inclined to a horizontal line DN, and let the body be let fall from the point A, so as to move along these planes, without losing any of its velocity at the angular points; it will have the same velocity when it reaches the horizontal plane at D, which it would have acquired by falling freely from A to F. It is manifest from Art. 220. that the velocity of the body when at B will be the same as that of another body which had fallen freely from A to c in a vertical line. The two bodies set out from B and c with the same velocity, and will therefore continue to have the same velocity when they reach the points C, G, because $c\,G = B\,d$. The two bodies again set off from the points C, G with the same celerity, and since $GF = Ce$, their respective velocities will be equal when they arrive at the points D, F in the horizontal plane. The velocity, therefore, acquired by the body falling along the planes AB, BC, CD is equal to that which is acquired by the same body falling through the vertical line AF.

224. Cor. 1. As the preceding proposition holds true, whatever be the number of inclined planes which lie between the point A and the horizontal line, it will hold true also of any curve line which may be considered as made up of an infinite number of straight lines. And, since the small planes are diminished without limit, the radius is diminished without limit, and therefore the versed sine, or the velocity lost in passing from one plane to another, is diminished without limit (A), consequently, abstracting from friction, a body will ascend or descend a curve surface without losing any of its velocity from the curvature of the surface.

225. Cor. 2. If a body be made to ascend a curve surface, or a system of inclined planes, the vertical height to which it will rise, is equal to that through which it must fall in order to acquire the velocity with which it ascended, abstracting from the effects of friction, and the velocity which is lost in passing from one plane to another. This is obvious, from Dynamics, § 26, 51.; for the body experiences the same decrements of velocity in its ascent, as it received increments in its descent.

226. Cor. 3. The same thing will hold if the body is kept in the curve by a string perpendicular to the curve, for the string sustains that part of the weight which was sustained by the curve, since the reaction of the curve surface is in a line perpendicular to the curve.

Scholium.

227. It is obvious, that the body which moves along the system of inclined planes must lose a part of its velocity in passing from one plane to another. By the resolution of motion it will be found that the velocity acquired by falling through any of the planes, is to the velocity lost in passing to the succeeding one, as radius is to the versed sine of the angle formed by the two planes. Or the velocity with which the body enters upon one plane is as the cosine of the angle made by the contiguous planes, divided by the velocity which the body had when it left the preceding plane.

Prop. III.

228. The times of descending two systems of inclined planes similar and similarly situated, are in the subduplicate ratio of their lengths.

Let AB, BC, CD, and $a\,b$, $b\,c$, $c\,d$ be the similar systems of inclined planes, and let T be the time of descending ABCD, and t the time of descending $a\,b\,c\,d$. Fig. 2.

By Cor. 4. Prop. 1. we have

$$\text{Time along AB} : \text{Time along A}\,c = AB : A\,c,$$
$$\text{Time along } a\,b : \text{Time along } \alpha\,\beta, = a\,b : \alpha\,\beta,$$

But, on account of the similar triangles AB c, $a\,b\,\beta$, we have,

$$AB : A\,c = a\,b : \alpha\,\beta.$$

Hence (Euclid, Book v. Prop. 11. 16.)

$$\text{Time along AB} : \text{Time along } a\,b = \text{Time along A}\,c : \text{Time along } \alpha\,\beta.$$

In

(A) See Wood's Principles of Mechanics, p. 58. note; and also Gregory's Mechanics, vol. i. p. 112. where this corollary is demonstrated by the method of fluxions.

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In the same way it may be shewn, that

$$\text{Time along BC : Time along } bc = \text{Time along } c\,\text{G : Time along } \beta\kappa,$$
$$\text{Time along CD : Time along } cd = \text{Time along GF : Time along } \kappa f.$$

Then, by GEOMETRY, Sect. III. Theorem VIII.

$$\text{Time along AB+BC+CD : Time along } \overline{ab+bc+cd} = \text{Time along } \overline{\text{A}c+c\text{G+GF}} \text{ : Time along } \overline{a\beta+\beta\kappa+\kappa f}$$

that is,

$$\text{Time along } \overline{\text{AB+BC+CD}} \text{ : Time along } \overline{ab+bc+cd} = \text{Time along AF : Time along } af.$$

But by DYNAMICS § 37, 2.

$$\text{Time along AF : Time along } af = \sqrt{\text{AF}} : \sqrt{af}.$$

Therefore, EUCLID, B. V. Prop. 11.

$$\text{Time along } \overline{\text{AB+BC+CD}} \text{ : Time along } \overline{ab+bc+cd} = \sqrt{\text{AF}} : \sqrt{af}. \quad \text{Q. E. D.}$$

But by similar triangles, &c.

$$\sqrt{\text{AF}} : \sqrt{af} = \sqrt{\text{AB+BC+CD}} : \sqrt{ab+bc+cd}.$$

Therefore,

$$\text{Time along } \overline{\text{AB+BC+CD}} \text{ : Time along } \overline{ab+bc+cd} = \sqrt{\text{AB+BC+CD}} : \sqrt{ab+bc+cd}. \quad \text{Q. E. D.}$$

229. COR. 1. This proposition holds true of curves, for the reasons mentioned in Prop. 2. Cor. 1.

230. COR. 2. The times of descent along similar arcs of a circle are as their radii; for by the preceding corollary the times are as the arcs, and the arcs are as the radii, therefore the times are as the radii.

PROP. IV.

231. An inverted semicycloid is the curve of quickest descent, or the curve along which a body must descend in order to move between two points not in a vertical line, in the least time possible.

Fig. 4. Let q FZ be a semicycloid, and A′D′, C′F′ two parallel and vertical ordinates at an infinitely small distance. Draw the ordinate B′E′ an arithmetical mean between the ordinates A′D′ and C′F′, and from F′, E′ draw F′v, E′u perpendicular to B′F, C′E′. Make C′F′$=a$, B′E′$=b$, E′$v=c$, C′B′$=m$, B′A′$=n$. Then since F′E′ may be considered as a straight line, and since B′C′$=$F′v, we have (Euclid, B. I. Prop. 47.) F′E′$=\sqrt{m^2+c^2}$, and since F′$v=$E′u, E′D′$=\sqrt{n^2+c^2}$. Now the velocities at F′ and E′ vary as $\sqrt{a}$ and $\sqrt{b}$, and F′E′, E′D′ are the elementary spaces described with these velocities; but the times are directly as the square root of the spaces, and inversely as the velocities, therefore the time of describing F′E′ is $\frac{\sqrt{m^2+c^2}}{\sqrt{a}}$, and the time of describing E′D′ is $\frac{\sqrt{n^2+c^2}}{\sqrt{b}}$, consequently, the time of describing FD must be $\frac{\overline{m^2+c^2}|^{\frac{1}{2}}}{a^{\frac{1}{2}}}+\frac{\overline{n^2+c^2}|^{\frac{1}{2}}}{b^{\frac{1}{2}}}$

But the proposition requires that this time should be the least possible or a minimum, therefore taking its fluxion and making it equal to o, we have

$$\frac{2m\dot{m}}{2\sqrt{a\times\overline{mm+c^2}}}+\frac{2n\dot{n}}{2\sqrt{b\times\overline{nn\times c^2}}}=\text{o}.$$

But since CA is invariable $m+n$ is invariable, and therefore its fluxion $\dot{m}+\dot{n}=$o, or $\dot{m}=-n$ and $\dot{n}=-m$, therefore by transposing the second number of the preceding equation, and substituting these values of $\dot{m}$ and $\dot{n}$, it becomes $\frac{m}{\sqrt{a\times\overline{m^2+c^2}}}=\frac{n}{\sqrt{b\times\overline{n^2+c^2}}}$. Let us now call the variable abscissa q C′$=x$, the ordinate C′F′$=y$ and the arc q F′$=z$, then m and n are fluxions of x, and F′E′ is the increment of q F or z, when y is equal to a, and E′D′ the increment of q F or z, when y is equal to b, therefore by substituting these values in the preceding equation, we obtain $\frac{\dot{x}'}{\sqrt{y\dot{z}'}}=\frac{\dot{x}'}{\sqrt{y\dot{z}'}}$, which shews that this quantity is constant, and gives us the following analogy, $\dot{z}' : \dot{x}' = 1 : \sqrt{y}$. Now in the cycloid $\sqrt{y}$ is always the chord of the generating circle when the diameter is y (for by Euclid, Book I. Prop. 47, Book II. Prop 8. and Book III. Prop. 35.) AF$=\sqrt{\text{AD}\times\text{AO}}$, and since AO$=1$ and AD$=y$, we have AF$=\sqrt{y}$. Fig. 5. But since the arc of the cycloid at F is perpendicular to the chord AF, the elementary triangle FEv is similar to FDO, (for BE is parallel to AO) and consequently to AFO (Euclid. B. VI. Prop. 8.), therefore, we have FE : E′ $\dot{z}'=$AO : AF; but FE$=\dot{x}'$, E$v=v$, AO$=1$ and AF$=\sqrt{y}$, consequently $\dot{z}' : \dot{x}' = 1 : \sqrt{y}$, which coincides with the analogy already obtained, and being the property of the cycloid shews that the curve of quickest descent is an inverted cycloidal arc.

Properties of the Cycloid.

Fig. 3. Properties of the cycloid.

DEFINITION.—If a circle NOP be so placed as to be in contact with the line AD, and be made to roll along that line from D towards A, till the same point D of the circle touches the other extremity A, the point D will describe a curve DBA, called a cycloid.

The line AD is called the *base of the cycloid*; the line CB, which bisects AD at right angles and meets the curve in B, is called the *axis*, and B the *vertex*.

The circle NOP is called the generating circle.

232. 1. The

Theory.

232. 1. The base AD is equal to the circumference of the generating circle, and AC is equal to half that circumference.

2. The axis CB is equal to the diameter of the generating circle.

3. If from any point G of the cycloid, there be drawn a straight line GM parallel to AD, and meeting the circle BLC in L, the circular arc BL is equal to the line GL.

4. If the points L, B be joined, and a tangent drawn to the cycloid at the point G, the tangent will be parallel to the chord LB, and the tangent is found by joining G, E, for GE is parallel to LB.

5. The arc BG of the cycloid is double of the chord BL, and the arc BA or BD is equal to twice the axis BC.

6. If the two portions AB, DB of the cycloid in fig. 3. be placed in the inverted position AB, DB (fig. 4.), and if a string BP equal in length to BA be made to coincide with BA, and then be evolved from it, its extremity P will describe a semicycloid AF, similar and equal to BA. In the same way the semicycloid DF, produced by the evolution of the string BP from the semicycloid BD, is equal and similar to BD and to AF. Therefore, if BP be a pendulum or weight attached to the extremity of a flexible line BP, which vibrates between the cycloidal cheeks BA, BD, its extremity D will describe a cycloid AFD, equal to that which is composed of the two halves BA, BD. Fig. 4.

7. The chord CN is parallel to MP, and MP is perpendicular to the cycloid AFD, at the point P.

8. If Pp be an infinitely small arc, the perpendicular to the curve drawn from the points Pp will meet at M, and Pp may be regarded as a circular arc, whose radius is MP. An infinitely small cycloidal arc at F may likewise be considered as a circular arc whose radius is BF.

As these properties of the cycloid are demonstrated in almost every treatise on mechanics, and as their demonstrations more properly belong to geometry than to mechanics, they are purposely omitted to make room for more important matter.

233. Definition.—If a body descend from any point of a curve, and ascend in the same curve till its velocity is destroyed, the body is said to oscillate in that curve, and the time in which this descent and ascent are performed is called the time of an oscillation or vibration.

234. Definition.—A cycloidal pendulum is a pendulum which oscillates or vibrates in the arch of a cycloid.

235. Definition.—Oscillations which are performed in equal times are said to be isochronous.

Prop. V.

Fig. 4. 236. The velocity of a cycloidal pendulum BP at the point F, varies as the arch which it describes.

The velocity of the pendulum at F is that which it would have acquired by falling through EF (Prop. 2. and Cor. 3. Prop. 2.), and the velocity of a falling body is as the square root of the space which it describes (Dynamics, § 37.), therefore the velocity of the pendulum P, when it reaches F, varies as $\sqrt{EF}$. But (Geometry, Sect. IV. Theor. 23. and 8.) FE varies as $\frac{FN^2}{FC}$, and since FC is a constant quantity, FE will vary as FN^2 varies, or, to adopt the notation used in the article Dynamics, $FE \doteq FN^2$, or $\sqrt{FE} \doteq FN$, but the velocity acquired by falling through EF varies as $\sqrt{FE}$, therefore the velocity of the pendulum at F varies as FN, that is, as FP, for (Art. 232. N° 5.) FN is equal to half FP. Q. E. D.

Prop. VI.

237. If the pendulum begins its oscillation from the point P, the velocity of the pendulum at any point R varies as the sine of a circular arc whose radius is FP, and whose versed sine is PR.

Through F draw $p\,F\,q$ parallel to AD, and with a radius equal to the cycloidal arc FP, describe the semicircle $p\,o\,q$. Make $p\,r$ equal to the arc PR of the cycloid, and through r draw $r\,m$ perpendicular to p F. Through the points P, R draw PE, RT parallel to AD, and cutting the generating circle CNF in the points N, S.—By Prop. 4. the velocity at R varies as $\sqrt{ET}$, that is, as $\sqrt{EF-TF}$, or since CF is constant, as $\sqrt{CF\times EF-CF\times TF}$, that is, as $\sqrt{FN^2-FS^2}$. For, (Playfair's Euclid, Book I. Prop. 47, Book II. Prop. 7. and Book III. Prop. 35.) $FN^2=CF\times EF$, and $FS=CF\times TF$), that is, as $\sqrt{4FN^2-FS4^2}$, that is (Art. 232. N° 5.) as $\sqrt{FP^2-FR^2}$. But F p or F m was made equal to FP, and, $p\,r$ being made equal to PR, the remainder F r must be equal to FR, therefore the velocity at R varies as $\sqrt{\overline{Fm}^2-\overline{Fr}^2}$, but (Euclid, 47. 1.) $r\,m=\sqrt{\overline{Fm}^2-\overline{Fr}^2}$, and $r\,m$ is by construction equal to the sine of a circular arc, whose radius is FP, and versed sine PR, consequently, the velocity at R varies as the sine of that arc. Q. E. D. Fig. 4.

238. Corollary. The velocity of the pendulum at F is to the velocity of the pendulum at R, as F m : $r.m$, for the versed sine is in this case equal to radius, and therefore the corresponding arc must be a quadrant whose sine is also equal to radius or F m.

Prop. VII.

239. The time in which the pendulum performs one complete oscillation from P to O, is equal to the time in which a body would describe the semicircle $p\,o\,q$, uniformly with the velocity which the pendulum acquires at the point F. Fig. 4.

Take any infinitely small arc RV, and making $r\,v$ equal to it, draw $v\,o$ parallel to $r\,m$, and $m\,n$ to $r\,v$. Now, by the last proposition, and by Dynamics, Art. 28.; the velocity with which RV is described is to the velocity with which $m\,o$ is described as $r\,m$ is to F m, that

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that is as $\frac{RV}{rm}:\frac{mo}{Fm}$, or as $\frac{mn}{rm}:\frac{mo}{Fm}$, for $mn=rv=RV$. But in the similar triangles Fmr, mno, $Fm:rm=mo:mn$, consequently $\frac{mn}{rm}=\frac{mo}{Fm}$, therefore the velocity with which RV is described is equal to the velocity with which mo is described, and the times in which these equal spaces are described must likewise be equal. The same thing may be demonstrated of all the other corresponding arcs of the cycloid and circle, and therefore it follows that the time in which the pendulum performs one complete oscillation is equal to the time in which the semicircle poq is uniformly described with the velocity acquired at F.

Prop. VIII.

240. **The time in which a cycloidal pendulum performs a complete oscillation is to the time in which a body would fall freely through the axis of the cycloid, as the circumference of a circle is to its diameter.**

Fig. 4. Since $FP=2FN$, and since the velocity acquired by falling down NF is equal to the velocity acquired by falling down PF, the body, if it continued to move uniformly with this velocity, would describe a space equal to 2PF (Dynamics, § 37. N° 6.) in the same time that it would descend NF or CF (Art. 219.). Calling T therefore the time of an oscillation, and t the time of descent along the axis, we have, by the preceding proposition,

$T=$time along poq, with the velocity at F,

and by the preceding paragraph,

$t=$time along Fp, with the same velocity; therefore

$T::t=$time along poq with velocity at V : time along Fp with the same velocity; that is, $T:t=poq:Fp$ $=2poq:2Fp=$the circumference of a circle : its diameter.

241. Cor. 1. The oscillations in a cycloid are isochronous, that is, they are performed in equal times whatever be the size of the arc which the pendulum describes. For the time of an oscillation has a constant ratio to the time of descent along the axis, and is therefore an invariable quantity.

242. Cor. 2. The oscillations in a small circular arc whose radius is BF, and in an equal arc of the cycloid, being isochronous (Art. 232. N° 8.), the time of an oscillation in a small circular arc will also be to the time of descent along the axis, as the circumference of a circle is to its diameter.

243. Cor. 3. Since the length BF of the pendulum is double of the axis CF, the time of an oscillation in a cycloid or small circular arc varies as the time of descending along CF, half the length of the pendulum, the force of gravity being constant. But the time of descent along CF varies as $\sqrt{CF}$, therefore the time of an oscillation in a small circular or cycloidal arc varies as the square root of half the length of the pendulum, or as the square root of its whole length. If T, t therefore be the times of oscillations of two pendulums, and L, l their respective lengths, we have by this corollary $T:t=\sqrt{L}:\sqrt{l}$, and $T\times\sqrt{l}=t\times\sqrt{L}$; hence $T=\frac{t\times\sqrt{L}}{\sqrt{l}}$; $t=\frac{T\times\sqrt{l}}{\sqrt{L}}$; $l=\sqrt{\frac{t\times\sqrt{L}}{T}}$, and $L=\sqrt{\frac{T\times\sqrt{l}}{t}}$, from which we may find the time in which a pendulum of any length will vibrate; a pendulum of 39.2 inches vibrating in one second.

Theory.

244. Cor. 4. When the force of gravity varies, which it does in going from the poles to the equator, the time of an oscillation is directly as the square root of the length of the pendulum, and inversely as the square root of the force of gravity. The time of an oscillation varies as the time of descent along half the length of the pendulum, and the time of descent through any space varies as $\frac{\sqrt{s}}{\sqrt{g}}$, where s is the space described and g the force of gravity; but in the present case $s=\frac{L}{2}$; therefore by substitution, the time of descent along half the length of the pendulum, or the time of an oscillation, varies as $\frac{\sqrt{\frac{1}{2}L}}{\sqrt{g}}$, or as $\frac{\sqrt{L}}{\sqrt{g}}$. Hence $T:t=\frac{\sqrt{L}}{\sqrt{g}}:\frac{\sqrt{l}}{\sqrt{g}}$, from which it is easy to deduce equations similar to those given in the preceding corollary.

245. Cor. 5. Since $T\doteq\frac{\sqrt{L}}{\sqrt{g}}$, $\sqrt{g}\times T\doteq\sqrt{L}$; and if the time of oscillation is 1 second, we have $\sqrt{g}\doteq\sqrt{L}$, or $g\doteq L$, that is, the force of gravity in different latitudes varies as the length of a pendulum that vibrates seconds.

246. Cor. 6. The number of oscillations which a pendulum makes in a given time, and in a given latitude, are in the inverse subduplicate ratio of its length. The number of oscillations n made in a given time are evidently in the inverse ratio of t, the time of each oscillation; that is $n\doteq\frac{1}{t}$; but by Corollary 3. $t\doteq\sqrt{l}$, therefore $n\doteq\frac{1}{\sqrt{l}}$, and $l\doteq\frac{1}{n^2}$, from which it is easy to find the length of a pendulum which will vibrate any number of times in a given time, or the number of vibrations which a pendulum of a given length will perform in a given time.

Prop. IX.

247. **To find the space through which a heavy body will fall in one second by the force of gravity.**

Since by Proposition 8. the time of an oscillation is to the time along half the length of the pendulum as 3.14159 is to 1, and since the spaces are as the squares of the times, the spaces described by a heavy body in the time of an oscillation will be to half the length of the pendulum as $\overline{3.14159}^2$ is to 1. Now it appears from the experiments of Mr Whitehurst, that the length of a pendulum which vibrates seconds at London at 113 feet above the level of the sea, in a temperature of

60° of Fahrenheit, and when the barometer is 30 inches, is 39.1196 inches; hence $1^2 : \overline{3.14159}|^2 = \frac{39.1196}{2} : 19.5598 \times \overline{3.14159}|^2 = 16.087$ feet the space required.

The methods of determining the centre of oscillation, gyration, and percussion, properly belong to this chapter, but they have been already given in the article ROTATION, to which we must refer the reader who wishes to prosecute the subject.

CHAP. VI. *On the Collision or Impulsion of Bodies.*

248. DEF. 1. When a body moving with a certain velocity strikes another body, either at rest or in motion, the one is said to impinge against, or to impell the other. This effect has been distinguished by the names collision, impulsion or impulse, percussion, and impact.

249. DEF. 2. The collision or impulsion of two bodies is said to be *direct* when the bodies move in the same straight line, or when the point in which they strike each other is in the straight line which joins their centres of gravity. When this is not the case, the impulse is said to be oblique.

250. DEF. 3. A *hard* body is one which is not susceptible of compression by any finite force. An *elastic* body is one susceptible of compression, which recovers its figure with a force equal to that which compresses it. A *soft* body is one which does not recover its form after compression. There does not exist in nature any body which is either perfectly hard, perfectly elastic or perfectly soft. Every body with which we are acquainted possesses elasticity in some degree or other. Diamond, crystal, agate, &c. though among the hardest bodies, are highly elastic; and even clay itself will in some degree recover its figure after compression. It is necessary, however, to consider bodies as hard, soft or elastic, in order to obtain the limits between which the required results must be contained.

251. DEF. 4. The mass of a body is the sum of the material particles of which it is composed; and the *momentum*, or *moving force*, or *quantity of motion* of any body, is the product arising from multiplying its mass by its velocity.

PROP. I.

252. **Two hard bodies B, B′ with velocities V, V′ striking each other perpendicularly, will be at rest after impulse, if their velocities are inversely as their masses.**

1. When the two bodies are equal, their velocities must be equal in the case of an equilibrium after impulse, and therefore $B : B' = V' : V$, or $BV = B'V'$; for if they are not at rest after impulse, the one must carry the other along with it: But as their masses and velocities are equal, there can be no reason why the one should carry the other along with it.

2. If the one body is double of the other, or $B = 2B'$, we should have $V' = 2V'$. Now instead of B we may substitute two bodies equal to B′, and instead of V′ we may substitute two velocities equal to V, with which the bodies B′ may be conceived to move; consequently we have $2B' \times V = B' \times 2V$, or $B' : 2B' = V : 2V$; but 2V is the velocity of B′, and V is the velocity of 2 B′, therefore when one body is double of the other, they will remain at rest when the masses of the bodies are inversely as their velocities.

In the same way the proposition may be demonstrated when the bodies are to one another in any commensurable proportion.

PROP. II.

253. **To find the common velocity v of two hard bodies B, B′ whose velocities are V, V′, after striking each other perpendicularly.**

If the bodies have not equal quantities of motion they cannot be in equilibrio after impulse. The one will carry the other along with it, and in consequence of their hardness, they will remain in contact, and move with a common velocity v.

1. In order to find this, let us first suppose B′ to be at rest and to be struck by B in motion. The quantity of motion which exists in B before impulse is BV, and as this is divided between the two bodies after impulse, it must be equal to the quantity of motion after impulse. But $v \times \overline{B + B'}$ is the quantity of motion after impulse, therefore $v \times \overline{B + B'} = BV$, and $v = \frac{BV}{B+B'}$.

2. Let us now suppose that both the bodies are in motion in the same direction that B follows B′. In order that B may impel B′, we must have V greater than V′. Now we may conceive both the bodies placed upon a plane moving with the velocity V′. The body B′, therefore, whose velocity is V′ equal to that of the plane, will be at rest upon the plane, while the velocity of B with regard to B′ or the plane, will be $V - V'$; consequently, the bodies are in the same circumstances as if B′ were at rest, and B moving with the velocity $V - V'$. Therefore, by the last case, we have the common velocity of the bodies in the moveable plane $\frac{BV - BV'}{B + B'}$; and by adding to this V′, the velocity of the plane, we shall have v, or the absolute velocity of the bodies after impulse, $v = \frac{BV + B'V'}{B + B'}$. Hence the quantity of motion, after impact, is equal to the sum of the quantities of motion before impact.

3. If the impinging bodies mutually approach each other, we may conceive, as before, that the body B′ is at rest upon a plane which moves with a velocity V′ in an opposite direction to V′, and that B moves on this plane with the velocity $V + V'$. Then, by Case 1. $\frac{BV + BV'}{B + B'}$ will be the common velocity upon the plane after impulse; and adding to this V′, or the velocity of the plane, we shall have v, or the absolute velocity of the bodies after impact, $v = \frac{BV - B'V'}{B + B'}$. Hence the quantity of motion after impact is equal to the difference of the quantities of motion before impact. It is obvious that v is positive or negative, according as BV is greater or less than B′V′, so that when BV is greater than B′V′, the bodies will move in the direction of B's

B's motion; and when BV is less than B'V', the bodies will move in the direction of A's motion.

254. All the three formulæ which we have given, may be comprehended in the following general formula, $v=\frac{BV\pm B'V'}{B+B'}$; for when B' is at rest, $V'=0$, and the formula assumes the form which it has in Case 1.

255. COR. 1. If $B=B'$, and the bodies mutually approach each other, the equation in Case 3. becomes $v=\frac{V-V'}{2}$, or the bodies will move in the direction of the quickest body, with a velocity equal to one half of the difference of their velocities.

256. COR. 2. If $V=V'$, and the bodies move in the same direction, the last formula will become $v=V\times\frac{B+B'}{B+B}$, or $v=V$; for in this case there can be no impulsion, the one body merely following the other in contact with it. When the bodies mutually approach each other, and when $V=V'$, we have $v=V+\frac{B-B'}{B+B}$.

257. COR. 3. When the bodies move in the same direction, we have, by Case 2. $v=\frac{BV+BV'}{B+B'}$. Now the velocity gained by B' is evidently $v-V'$, or $\frac{BV+B'V'}{B+B'}-V$ $=\frac{BV-BV'}{B+B'}$; hence $B+B':B=V-V':\frac{BV-BV'}{B+B'}$; but this last term is the velocity gained by B, and $V-V'$ is the relative velocity of the two bodies. Therefore, *in the impact of two hard bodies moving in the same direction*, $B+B'$: B *as the relative velocity of the two bodies is to the velocity gained by* B'. It is obvious also that the velocity lost by B is $V-v=V-\frac{BV+B'V'}{B+B'}$ or $\frac{B'V-B'V'}{B+B'}$; hence $B+B':B'=V-V':\frac{B'V-B'V'}{B+B}$; but this last term is the velocity lost by B, and $V-V'$ is the relative velocity of the bodies, therefore *in the impact of two hard bodies* $B+B'$: B' *as their relative velocity is to the velocity lost by* B. The same thing may be shewn when the bodies move in opposite directions, in which case their relative velocity is $V+V'$.

PROP. III.

258. To determine the velocities of two elastic bodies after impulse.

If an elastic body strikes a hard and immoveable plane, it will, at the instant of collision, be compressed at the place of contact. But as the elastic body instantaneously endeavours to recover its figure, and as this force of restitution is equal and opposite to the force of compression, it will move backwards from the plane in the same direction in which it advanced.—If two elastic bodies, with equal momenta, impinge against each other, the effect of their mutual compression is to destroy their relative velocity, and make them move with a common velocity, as in the case of hard bodies. But by the force of restitution, equal to that of compression, the bodies begin to recover their figure,—the parts in contact serve mutually as points of support, and the bodies recede from each other. Now, before the force of restitution began to exert itself, the bodies had a tendency to move in one direction with a common momentum; therefore, the body whose effort to recover its figure was in the same direction with that of the common momentum, will move on in that direction, with a momentum or moving force equal to the sum of the force of restitution and the common momentum; while the other body, whose effort to recover from compression is in a direction opposite to that of the common momentum, will move with a momentum equal to the difference between its force of restitution and the common momentum, and in the direction of the greatest of these momenta: After impulse, therefore, it either moves in the direction opposite to that of the common momentum, or its motion in the same direction as that of the common momentum is diminished, or it is stopped altogether, according as the force of restitution is greater, less, or equal to the common momentum.

259. In order to apply these preliminary observations, let us adopt the notation in the two preceding propositions, and let v be the common velocity which the bodies would have received after impulse, if they had been hard, and v', v'' the velocities which the elastic bodies B, B' receive after impact.

260. 1. If B follows B', then V is greater than V', and when B has reached B', they are both compressed at the point of impact. Hence, since v is the common velocity with which they would advance if the force of restitution were not exerted, we have $V-v=$ the velocity lost by B, and $v-V'=$ the velocity gained by B' in consequence of compression.—But, when the bodies strive to recover their form by the force of restitution, the body B will move backwards in consequence of this force, while B' will move onward in its former direction with an accelerated velocity. Hence, from the force of restitution, B will again lose the velocity $V-v$, and B' will, a second time, gain the velocity $v-V'$; consequently, the whole velocity lost by B is $2V-2v$, and the whole velocity gained by B' is $2v-2V'$. Now, subtracting this loss from the original velocity of B, we have $V-\overline{2V-2v}$, for the velocity of B after impact, and adding the velocity gained by B to its original velocity, we have $V'+\overline{2v-2V'}$ for the velocity of B' after impact; hence we have

$$v'=V-\overline{2V-2v}=2v-V$$
$$v''=V'+\overline{2v-2V'}=v-V.$$

Now, substituting in these equations, the value of v as found in Case 2. Prop. 2. we obtain

$$v'=\frac{BV-B'V+2B'V'}{B+B'}$$
$$v''=\frac{BV'-B'V'+2BV}{B+B'}.$$

261. 2. When the bodies move in opposite directions or mutually approach each other, the body A is in precisely the same circumstances as in the preceding case; but

but the body B′ loses a part of its velocity equal to $\overline{2v+2V'}-V'$. Hence we have, by the same reasoning that was employed in the preceding case,

$$v'=2v-V'$$
$$v''=2v+V',$$

and by substituting instead of v its value, as determined in Case 3. Prop. 2. or by merely changing the sign of V′ in the two last equations in the preceding corollary, we obtain the two following equations, which will answer for both cases, by using the upper sign when the bodies move in the same direction, and the under sign when they move in opposite directions.

$$v'=\frac{BV-B'V\pm 2B'V'}{B'+B'}$$

$$v''=\frac{\pm BV'\pm B'V'+2BV}{B+B'}.$$

From the preceding equation the following corollaries may be deduced.

262. Cor. 1. The velocity gained by the body that is struck, and the velocity lost by the impinging body, are twice as great in elastic as they are in hard bodies; for in hard bodies the velocities gained and lost were $v-V'$, and $V-v$; whereas in elastic bodies the velocities gained and lost were $2v-2V'$, and $2V-2v$.

263. Cor. 2. *If one of the bodies, suppose* B′, *is at rest*, its velocity $V'=0$, and the preceding equation becomes

$$v'=\frac{VB-VB'}{B+B'};\ v''=\frac{2VB}{B+B'}.$$

264. Cor. 3. If one of the bodies B′ is at rest, and their masses equal, we have B=B′ and $V'=o$, by substituting which in the preceding formulæ, we obtain $v'=o$, and $v''=V$; that is, the impinging body B remains at rest after impact, and the body B′ that is struck when at rest moves on with the velocity of the body B that struck it, so that there is a complete transfer of B's velocity to B′.

265. Cor. 4. If B′ is at rest and B greater than B′, both the bodies will move forward in the direction of B's motion; for it is obvious from the equations in Cor. 2. that when B is greater than B′, v', and v'' are both positive.

266. Cor. 5. If B′ is at rest, and B less than B′, the impinging body B will return backwards, and the body B′ which is struck will move forward in the direction in which B moved before the stroke. For it is evident that when B is less than B′, v' is negative, and v'' positive.

267. Cor. 6. *If both the bodies move in the same direction*, the body B′ that is struck will after impact move with greater velocity than it had before it. This is obvious from the formula in Case 1. of this proposition.

268. Cor. 7. *If the bodies move in the same direction*, and if B=B′, there will at the moment of impact be a mutual transfer of velocities, that is, B will move on with B′'s velocity, and B′ will move on with B's velocity. For in the formulæ in Case 1. when B=B, we have $v'=V'$ and $v''=V$.

269. Cor. 8. *When the bodies move in opposite directions*, or mutually approach other, and when B=B′ and $V=V'$, both the bodies will recoil or move backwards after impact with the same velocities which they had before impact. For in the formulæ in Case 2. with the inferior signs, when B=B′ and $V=V'$, we have $v'=-V$ and $v''=V'$.

270. Cor. 9. If the bodies move in opposite directions, and $V=V'$, we have $v'=V\times\frac{B-3B'}{B+B'}$, and $v''=V\times\frac{3B-B'}{B+B'}$. Hence it is obvious, that if B=3 B′, or if one of the impinging bodies is thrice as great as the other, the greatest will be stopped, and the smallest will recoil with a velocity double of that which it had before impact. For since B=3 B′, by substituting this value of B in the preceding equations, we obtain $v'=o$, and $v''=2V$.

271. Cor. 10. If the impinging bodies move in opposite directions, and if B=B′, they will both recoil after a mutual exchange of velocities. For when B=B′, we have $v'=-V'$, and $v''=V$.

272. Cor. 11. When the bodies move in opposite directions, the body which is struck, and the body which strikes it, will stop, continue their motion, or return backwards, according as $BV-B'V$ is equal to, or greater or less than $2B'V'$.

273. Cor. 12. The relative velocity of the bodies after impact, is equal to their relative velocity before impact, or, which is the same thing, at equal instants before and after impact, the distance of the bodies from each other is the same. For in the different cases we have $v'=2v-V$; $v''=2v\mp V'$. But the relative velocity before impact is in the different cases $V\mp V'$, and the relative velocity after impact is $v'-v'=V\mp V'$.

274. Cor. 13. By reasoning similar to that which was employed in Prop. 2. Cor. 3. it may be shewn that B+B′ : 2 B as their relative velocity before impact is to the velocity gained by B′ in the direction of B's motion; and B+B′ : 2 B′ as their relative velocity before impact is to the velocity lost by B in the direction of A's motion.

275. Cor. 14. This *vis viva*, or the sum of the products of each body multiplied by the square of its velocity, is the same before and after impact, that is, $Bv'^2+B'v''^2=BV^2+B'V'^2$. From the formulæ at the end of Case 2. we obtain

$$Bv'^2=\frac{\overline{B-B'}|^2\times\overline{BV^2+B'V'^2}}{\overline{B+B'}|^2}\text{ and}$$

$$B'v''^2=\frac{4BB'\times\overline{BV^2+B'V'^2}}{\overline{B+B'}|^2},\text{hence their sum }Bv'^2\times B'v''^2$$

$$=\frac{\overline{B-B'}|^2\times\overline{BV^2+B'V'^2}+4BB'\times\overline{BV^2+B'V'^2}}{\overline{B+B'}|^2}=$$

$$\frac{\overline{BV^2+B'V'^2}\times\overline{B^2-B'^2+4BB'}}{B+B'^2}=BV^2+B'V'^2.$$

276. Cor. 15. If several equal elastic bodies B, B″. B‴, B⁗, &c. are in contact, and placed in the same straight line, and if another elastic body β of the same magnitude impinges against B, they will remain at rest, except the last body B⁗, which will move on with the velocity of β. By Art. 264. B will transfer to

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to B'' all its velocity, and therefore B will be at rest, in the same way B'' will transfer to B''' all its velocity, and B'' will remain at rest, and so on with the rest; but when the last body B'''' is set in motion, there is no other body to which its velocity can be transferred, and therefore it will move on with the velocity which it received from B''', that is, with the velocity of β.

277. Cor. 16. If the bodies decrease in size from B to B'''', they will all move in the direction of the impinging body β, and the velocity communicated to each body will be greater than that which is communicated to the preceding body.

278. Cor. 17. If the bodies increase in magnitude, they will all recoil, or move in a direction opposite to that of β, excepting the last, and the velocity communicated to each body will be less than that which is communicated to the preceding body.

Prop. IV.

279. To determine the velocities of two imperfectly elastic bodies after impulse, the force of compression being in a given ratio to the force of restitution or elasticity.

Let B, B' be the two bodies, V, V' their velocities before impact, v', v'' their velocities after impact, and $1 : n$ as the force of compression is to that of restitution. It is evident from Case 1. Prop. 8. that in consequence of the force of compression alone we have,

$$\left.\begin{array}{l} V-v=\text{velocity lost by B} \\ v-V'=\text{velocity gained by B}' \end{array}\right\}\text{from compression.}$$

But the velocity which B loses and B' gains by the force of compression will be to the velocity which B loses and B' gains by the force of restitution or elasticity as $1 : n$; hence

$$\left.\begin{array}{l} 1 : n=V-v : nV-nv,\text{ the velocity lost by B} \\ 1 : n=v-V' : nv-nV'\text{ the velocity gained by B} \end{array}\right\}\text{from elasticity.}$$

therefore by adding together the two portions of velocity lost by B, and also those gained by B', we obtain

$\overline{1+n}\,V-\overline{1+n}\,v$, the whole velocity lost by B,
$\overline{1+n}\,v-\overline{1+n}\,V'$, the whole velocity gained by B.

Hence by subtracting the velocity lost by B in consequence of collision from its velocity before impact, we shall have v' or the velocity of B after impact, and by adding the velocity gained by B' after collision to its velocity before impact, we shall find v'' or the velocity of B' after impact, thus

$v'=V-\overline{1+n}V-\overline{1+n}v$ the velocity of B after impact.
$v''=V'+\overline{1+n}v-\overline{1-n}V'$ the velocity of B after impact.

Now by substituting in the place of v its value as determined in Case 2. Prop. 2. we obtain

$$v'=V-\frac{\overline{1+n}\times\overline{B'V-B'V'}}{B+B'}.$$

$$v'=V+\frac{\overline{1+n}\times BV-BV'}{B+B}.$$

280. Cor. 1. Hence by converting the preceding equation into analogies, $B+B : \overline{1+n}\times B$ as the relative velocity of the bodies before impact is to the velocity gained by B' in the direction of B's motion; and $B+B' : 1+n\times B'$ as the relative velocity of the bodies before impact is to the velocity lost by B.

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281. Cor. 2. The relative velocity before impact is to the relative velocity after impact as the force of compression is to the force of restitution, or as $1 : n$.

The relative velocity after impact is $v''-v'$, or taking the preceding values of these quantities $v''-v'=V'$ $+\dfrac{\overline{1+n\times\overline{BV-BV'}}}{B+B'}-V-\dfrac{\overline{1+n+\overline{B'V-B'V'}}}{B+B'}=V'-V+\dfrac{\overline{1+n}\times\overline{B+B'}\times\overline{V-V'}}{B+B'}$, dividing by $B+B'$ we have $v''-v'=V'-V+V-V'+n\times\overline{V-V'}=n\times\overline{V-V'}$ $=$ the relative velocity after impact. But the relative velocity before impact is $V-V'$, and $V-V' : n\times\overline{V-V'}=1 : n$. Q. E. D. The quantity V' has evidently the negative sign when the bodies move in opposite directions.

282. Cor. 3. Hence from the velocities before and after impact we may determine the force of restitution or elasticity.

Prop. V.

283. To find the velocity of a body, and the direction in which it moves after impinging upon a hard and immoveable plane.

When the body is perfectly hard. Fig. 6.

283. Case 1. *When the impinging body is perfectly hard.* Let AB be the hard and immoveable plane, and let the impinging body move towards AB in the direction CD, and with a velocity represented by CD. Then the velocity CD may be resolved into the two velocities, CM, MD, or MD, FD; CM DF being a parallelogram. But the part of the velocity FD, which carries the body in a line perpendicular to the plane, is completely destroyed by impact, while the other part of the velocity MD, which carries the body in a line parallel to the plane, will not be affected by the collision, therefore the body will, after impact, move along the plane with the velocity MD. Now, CD : MD=radius : cos.∠CDM, therefore since MD =CF the sine of the angle of incidence CDF, the *velocity before impact is to the velocity after impact, as radius is to the sine of the angle of incidence;* and since AM=CD−MD, *the velocity before impact is to the velocity lost by impact, as radius is to the versed sine of the complement of the angle of incidence.*

When the body is perfectly elastic.

285. Case 2. *When the impinging body is perfectly elastic.* Let the body move in the direction CD with a velocity represented by CD, which, as formerly, may be resolved to MD, FD. The part of the velocity MD remains after impact, and tends to carry the body parallel to the plane. The other part of the velocity FD is destroyed by compression; but the force of restitution or elasticity will generate a velocity equal to FD, but in the opposite direction DF. Consequently the impinging body after impact is solicited by two velocities, one of which would carry it uniformly from D to F in the same time that the other would carry it uniformly from M to D, or from D to N; the body will, therefore

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therefore, move along DE, the diagonal of the parallelogram DFEN, which is equal to the parallelogram DFCM. Hence the angle CDF is equal to the angle EDF, therefore, when *an elastic body impinges obliquely against an immoveable plane, it will be reflected from the plane, so that the angle of reflexion is equal to the angle of incidence.* Since CD, DE are equal spaces described in equal times, the velocity of the body after impact will be equal to its velocity before impact.

When the body is imperfectly elastic.

286. Case 3. *When the impinging body is imperfectly elastic.* In DF take a point *m*, so that DF is to D *m* as the force of compression is to the force of restitution or elasticity, and having drawn *m c* parallel to DB, and meeting NE in *c*, join D *c*; then, if the impinging body approach the plane in the direction CD, with a velocity represented by CD, D *c* will be the direction in which it will move after impact. Immediately after compression, the velocity DF is destroyed as in the last case, while the velocity MD tends to carry the body parallel to the plane. But, by the force of restitution, the body would be carried uniformly along D *m*, perpendicular to the plane, while, by the velocity MD= DN—*m c*, it would be carried in the same time along *m c*, consequently, by means of these two velocities, the body will describe D *c*, the diagonal of the parallelogram D *m e* N. The velocity, therefore, before impact is to the velocity after impact as DC : D *c*, or as DE : D *c*, or as sin. D *c* E, sin. DE *c*, or as sin. D *c m*: sin. DE *c*, or as sin. FD *c* : sin. FDE. Now, by producing D *c* so as to meet the line CE produced in G, we have, on account of the parallels FE, *m c*, D *m* : DF =*m c* : FG; but, FD being radius, FE is the tangent of FDE, or FDG the angle of incidence, and FDG is the tangent of the angle of reflexion FDG: Therefore D *m* : DF=tang. ∠CDF : tang. ∠FDG. Consequently, *when an imperfectly elastic body impinges against a plane,* it will be reflected in such a manner *that the tangent of the angle of reflexion is to the tangent of the angle of incidence, as the force of compression is to the force of restitution or elasticity; and the velocity before incidence will be to the velocity after reflexion, as the sine of the angle of reflexion is to the sine of the angle of incidence.*

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287. When the surface against which the body impinges is curved, we must conceive a plane touching the surface at the place of incidence, and then apply the rules in the preceding proposition. The doctrine of the oblique collision of bodies is of great use both in acoustics and optics, where the material particles which suffer reflexion are regarded as perfectly elastic bodies.

Prop. VI.

288. To find the point of an immoveable plane which an elastic body moving from a given place must strike, in order that it may, after reflexion, either from one or two planes, impinge against another body whose position is given.

Fig. 7.

289. Case 1. *When there is only one reflexion.* Let C be the place from which the impinging body is to move, and let E be the body which is to be struck after reflexion from the plane AB. From C let fall CH perpendicular to AB, continue it towards C till HG=CH, and join G, E by the line GDE; the point D where this line cuts the plane, is the place against which the body at C must impinge in order that, after reflexion, it may strike the body at E. The triangles CDH, HDG are equiangular, because two sides and one angle of each are respectively equal, therefore the angles DCH, DGH are equal. But on account of the parallels FD, CG the angle EDF=DGC=DCH, and DCH= FDC, therefore the angle of incidence FDC=FDE the angle of reflexion; consequently by Prop. 4. a body moving from C and impinging on the plane at D will, after reflexion, move in the line DE, and strike the body at E.

290. Case 2. *When there are two reflexions.* Let AB, BL, be the two immoveable planes, C the place from which the impinging body is to move, and F the body which it is to strike after reflexion from the two planes, it is required to find the point of impact D. Draw CHG perpendicular to AB, so that HG=CH. Through G draw GMN parallel to AB, cutting LB produced in M, and make GM=MN. Join N, F, and from the point E, where NF cuts the plane BL, draw EG, joining the points EG: the point D will be the point of the plane, against which the body at C must impinge, in order to strike the body at F. By reasoning as in the preceding case, it may be shewn that the angle CDH=EDB, therefore DE will be the path of the body after the first reflexion. Now, the triangles GEM, EMN are equiangular, because GM =MN, and the angles at M right, therefore DEB= FEL, that is, the body after reflexion at E will strike the body placed at F. Fig. 8.

Prop. VII.

291. To determine the motions of two spherical bodies which impinge obliquely upon each other, when their motion, quantities of matter, and radii, are given.

Let A, B be the two bodies, and let CA, DB be the directions in which they move before impact, and let these lines represent their respective velocities. Join A, B the centres of the bodies, and produce it both ways to K and I. Draw LM perpendicular to IK, and it will touch the bodies at the point of impact. Now, the velocity CA may be resolved into the two velocities CI, IA, and the velocity DB into the velocities DK, KB, but CA and DB are given, and also the angles CAI, DBK, consequently CI and IA, and DK and KB may be found. The velocities CI, DK, which are parallel to the plane, will not be altered by collision, therefore IA, KB are the velocities with which the bodies directly impinge upon each other, consequently their effects or the velocities after impact may be found from Prop. 3.; let these velocities be represented by AN, BP. Take AF=CI and BH=DM, and having completed the parallelograms AFON, BPQH, draw the diagonals AO, QB. Then, since the body A is carried parallel to the line LM with a velocity CI=AF, and from the line LM by the velocity AN, it will describe AO, the diagonal of the parallelogram Fig. 9.

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rallelogram NF; and for the same reason the body B will describe the diagonal BQ of the parallelogram PH.

Fig. 10. 292. COROLLARY. If A=B, and if the body which is struck moves in a given direction and with a given velocity after impact, the direction of the impinging body, and the velocity of its motion, may be easily found. Let the body D impinge against the equal body C, and let CB be the direction in which C moves after impact, it is required to find the direction in which D will move. Draw D c, touching the ball C at c, the place where the ball D impinges; produce BC to E, and through c draw A c F perpendicular to EB, and complete the rectangle FE. The force D c may be resolved into the forces E c, c F, of which E c is employed to move the ball C in the direction CB and with the velocity E c; but the force c F has no share in the impulse, and is wholly employed in making the body D move in the direction CA, and with the velocity CF.

SCHOLIUM.

The phenomena of impulsion owing to repulsive forces which prevent bodies from coming into mathematical contact.

293. In the preceding proposition, we have endeavoured to give a short and perspicuous view of the common theory of impulsion. The limits of this article will not permit us to enter upon those interesting speculations to which this subject has given rise; but those who are anxious to pursue them will find ample assistance in the article IMPULSION, in the Supplement to the last edition of this work, where Dr Robison has treated the subject with his usual ability. It may be proper however to remark, that all the phenomena of impulse as well as pressure, are owing to the existence of forces which prevent the particles of matter from coming into mathematical contact. The body which is struck, in the case of collision, is put in motion by the mutual repulsion of the material particles at the point of impact, while the velocity of the impinging body is diminished by the same cause. Hence we see the absurdity of referring all motion to impulse, or of attempting to account for the phenomena of gravitation, electricity, and magnetism by the intervention of any visible fluid. Even if the supposition that such a medium exists were not gratuitous, it would be impossible to shew that its particles, by means of which the impulse is conveyed, are in contact with the particles of the body to which that impulse is communicated.

Don Georges Juan's physico-mathematical theory of percussion.

294. A physico-mathematical theory of percussion, in which the impinging bodies are considered as imperfectly elastic, has been lately given by Don Georges Juan, in his *Examen Maritimo*, a Spanish work which has been translated with additions by M. L'Eveque, under the title of *Examen maritime, theorique et pratique, ou Traite de mecanique, applique a la construction, et a la manœuvre des vaisseaux et autres batimens.* This theory has been embraced by many eminent French philosophers, and may be seen in Prony's *Architecture Hydraulique*, vol. i. p. 208, and in Gregory's Mechanics, vol. i. p. 291. We shall endeavour, under the article PERCUSSION, to give a short account of this interesting theory, which has been found to accord with the most accurate experiments.

295. In some cases of collision the results of experiments are rather at variance with those of theory, in consequence of the communication of motion not being exactly instantaneous. "If an ivory ball (says Mr Leslie) strikes against another of equal weight, there should, according to the common theory, be an exact transfer of motion. But if the velocity of the impinging ball be very considerable, so far from stopping suddenly, it will recoil back again with the same force, while the ball which is struck will remain at rest; the reason is, that the shock is so momentary, as not to permit the communication of impulse to the whole mass of the second ball, a small spot only is affected, and the consequence is therefore the same as if the ball had impinged against an immoveable wall. On a perfect acquaintance with such facts depends, in a great measure, the skill of the billiard player. It is on a similar principle that a bullet fired against a door which hangs freely on its hinges will perforate without agitating it in the least. Nay, a pellet of clay, a bit of tallow, or even a small bag of water, discharged from a pistol will produce the same effect. In all these instances the impression of the stroke is confined to a single spot, and no sufficient time is allowed for diffusing its action over the extent of the door. If a large stone be thrown with equal momentum, and consequently with smaller velocity, the effect will be totally reversed, the door will turn on its hinges, and yet scarcely a dent will be made on its surface. Hence likewise the theory of most of the tools, and their mode of application in the mechanical arts: the chisel, the saw, the file, the scythe, the hedge bill, &c.—In the process of cutting, the object is to concentrate the force in a very narrow space, and this is effected by giving the instrument a rapid motion. Hence, too, the reason why only a small hammer is used in rivetting, and why a mallet is preferred for driving wedges." *Enquiry into the Nature of Heat*, p. 127,8.

Successive propagation of motion illustrated. Fig. 11.

296. The successive propagation of motion may be illustrated by a very simple experiment. Take two balls A, B, of which B is very large when compared with A, and connect them by a string S passing over the pulley P. If the ball B is lifted up towards S and allowed to fall by its own weight, instead of bringing the little ball A along with it, as might have been expected, the string will break at P. Here it is evident that the motion is not propagated instantaneously, for the string is broken before the motion is communicated to the portion of the string between P and A.

Apparatus for experiments on collision. Fig. 12.

297. An apparatus for making experiments on the collision of bodies is represented in fig. 12. The impinging bodies are suspended by threads like pendulums, and as the velocities acquired by descending through the arches of circles are in the ratio of their chords, the velocities of the impinging bodies may be easily ascertained. The apparatus is therefore furnished with a graduated arch MN which is generally divided into equal parts, though it would be more convenient to place the divisions at the extremities of arcs whose chords are expressed by the corresponding numbers. The balls that are not used may be placed behind the arc as at m and n; and in order to give variety to the experiments, the balls may be of different sizes. Sometimes a dish like G is attached to the extremities of the strings, for the purpose of holding argillaceous balls, and balls of wax softened with a quantity of oil equal to one-fourth part of their weight.—See *Smeaton's Experiments on the Collision of Bodies.*

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Chap. VII. *On the Maximum Effects of Machines.*

298. We have already seen in some of the preceding chapters, that when two bodies act upon each other by the intervention either of a simple or compound machine, there is an equilibrium when the velocity of the power is to the velocity of the weight as the weight is to the power. In this situation of equilibrium, therefore, the velocity of the weight is nothing, and the power has no effect in raising the weight, or, in other words, the machine performs no work. When the weight to be raised is infinitely small, the velocity is the greatest possible; but in this case likewise, the machine performs no work. In every other case, however, between these two extremes, some work will be performed.—In order to illustrate this more clearly, let us suppose a man employed in raising a weight by means of a lever with equal arms; and that he exerts a force upon the extremity of the lever, equivalent to 50 pounds. If the weight to be raised is also 50 pounds, there will be an equilibrium between the force of the man and the weight to be raised, the machine will remain at rest, and no work will be performed. If the man exert an additional force of one pound, or if his whole force is 51 pounds, the equilibrium will be destroyed, the weight will rise with a very slow motion, and the machine will therefore perform some work. When the motion of the machine therefore is $=0$ the work performed is also nothing, and when the machine is in such a state that the power preponderates, the work performed increases. Let us now suppose that the weight suspended from the lever is infinitely small, the motion of the machine will then be the greatest possible; but no work will be performed. If the weight however is increased, the motion of the machine will be diminished, and work will be performed. Here then it is evident that the work performed increases from nothing when the velocity is a maximum, and decreases to nothing when the velocity is a minimum. There must therefore be a particular velocity when the work performed is a *maximum*, and this particular velocity it is our present object to determine. Sometimes, indeed, the velocities of the machine are determined by its structure, and therefore it is out of the power of the machine to obtain a maximum effect by properly proportioning them. The same object however may be obtained, by making the work to be performed, or the resistance to be overcome, in a certain proportion to the power which is employed to perform the work or overcome the resistance.

299. Def. 1.—In a machine performing work, the powers employed to begin and continue the motion of the machine, are called the *first movers*, *the movers of powers*; and those powers which oppose the production and continuance of motion are called *resistances*. The friction of the machine, the inertia of its parts, and the work to be performed, all oppose the production and continuance of motion, and are therefore the resistances to be overcome. When various powers act at the same time, and in different directions, the equivalent force which results from their combined action is called the *moving force*, and the force resulting from all the resisting forces, the *resistance*. If the machine, for example, is a lever AB moving round the centre F, by means of which, two men raise water out of two pump barrels by the chains Au, Cw attached to the pistons, and passing over the arched heads or circular sectors M, N, for the purpose of giving the pistons and chains a vertical motion. Let the force of the man at B, six feet from F, be equal to 50 pounds, or π, his mechanical energy to turn the lever is $6\times 50=300$. Let the force of the other man applied at E, four feet from F, be also equal to 50 pounds, or p. His mechanical energy will be $4\times 50=200$, so that the whole moving power is equal to $300+200=500$. But if the two forces of 50 pounds, instead of being applied at two different distances from F, had been applied at the same point G, 5 feet from F, their energy to turn the lever would have been the same, for $5\times 50+50=500$. In the present case, therefore, the *moving force* is equivalent to $P\times GF$, or a force of 100 pounds acting at a distance of five feet from the centre of motion. Now let us suppose that each piston $A\,u$, $C\,w$ raises 60 pounds of water equivalent to the weights u, w, and that $CF=2$ feet, and $AF=3$ feet, then the mechanical energy of these weights will be respectively $2\times 60=120$, and $3\times 60=180$, and the sum of their energies $=300$. But two forces of 60 pounds each, acting at the distances two feet and three feet from F, are equivalent to their sum $=120$ pounds, acting at a distance of two feet and a half from F, for $2\frac{1}{2}\times 120=300$; therefore, the resistance arising from the work to be performed, or from the water raised in the pump barrels, is equal to a weight P of 120 pounds acting at the distance $DF=2\frac{1}{2}$ feet. But in addition to the resistance arising from the work to be performed, the two men have to overcome the resistance arising from the friction of the piston in the barrels, which we may suppose equivalent to f, φ, each equal to 10 pounds, acting at the points A, C; but these forces are equivalent to 20 pounds, or $f+\varphi$ acting at D, therefore the resistance arising from the work and from friction is equal to 140 pounds, acting at the distance $DF=2$ feet and a half. While the two men are employed in overcoming these resistances, they have also to contend against the inertia of the beam AF, and that of the chains and pistons, which we may suppose equal to 20 pounds when collected in their centre of gravity g, whose distance from F is 2.2 feet; but a weight of 20 pounds acting at the distance of 2.2 feet is equivalent to a weight of $19\frac{1}{2}$ pounds, acting at the distance of 2.5 feet, or DF, consequently the sum of all the resistances when reduced to the same point D of the lever is equal to $159\frac{1}{2}$ pounds acting at the distance of 2.5 feet from F. The mechanical energy, therefore, of the sum of all the resistances will be $=2.5\times 159\frac{1}{2}=398.75$, while the energy of the moving force, or the sum of all the moving powers, is equal to 500.

Plate CCCXXII. fig. 1.

300. Def. 2.—The *impelled point* of a machine is that point to which the moving power is applied, if there is only one power, or that point to which all the moving powers are reduced, or at which the moving force is supposed to act. The *working point* of a machine is that point at which the resistance acts if it is single, or that point to which all the resistances are reduced, and at which they are supposed to act when combined. Thus in fig. 1. G is the impelled point of the machine, and D the working point. Had a single force π been applied at the point B to raise a single weight u, acting at

Fig. 1.

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at the point A, then B would have been the impelled point, and A the working point of the machine. In the wheel and axle, the point of the wheel at which the rope touches its circumference is the impelled point, while the working point is that point in the circumference of the axle where the rope which carries the weight is in contact with it.

301. Def. 3.—The velocity of the moving power, and the velocity of the resistance, are respectively the same as the velocity of the impelled point, and the velocity of the working point.

302. Def. 4.—The *effect* of a machine, or the *work performed*, is equal to the resistance multiplied by the velocity of the working point; for when any machine raises a mass of matter to a given height in a certain time, the effect produced is measured by the product of the mass, and the height through which it rises, that is, by the product of the mass by the velocity with which it moves.

303. Def. 5.—The *momentum of impulse* is equal to the moving force multiplied by the velocity of the impelled point.

Explanation of symbols.

304. In any machine that has a motion of rotation, let x be the velocity of the impelled point, and y the velocity of the working point. When the machine is a lever, x, y will express the perpendiculars let fall from the centre of motion upon the line of direction in which the forces act; and if the machine is a wheel and axle, x, y will represent the diameters of the wheel and the axle respectively. In compound machines, which may be regarded as composed of levers, (Art. 90.) x will represent the sum of all the levers by which the power acts, and y the sum of all the levers by which the resistance acts.

305. Let P be the real pressure which the moving power exerts at the impelled point of the machine, and R the actual pressure which the mere resistance of the work to be performed exerts at the working point, or which it directly opposes to the direction of the power. Let a be the inertia of the power P, or the mass of matter which the power P must move with the velocity of the impelled point, in order that P may exert its pressure at the impelled point; and let b be the inertia of the resistance R, or the mass of matter which must be moved with the velocity of the working point in the performance of the work.

306. Since the resistance arising from the friction of the communicating parts is an uniformly retarding force, it may be measured by a weight φ acting at the working point of the machine, which will oppose the same resistance to the moving power as the friction of the parts.

307. Let m be the inertia of the machine, or rather that quantity of matter, which acting at the working point of the machine will require the same part of the moving force to give it an angular motion, then since y represents the arm of the lever by which the resistance acts, or the distance of the working point from the centre of motion; and since the momentum of inertia, or the momentum with which any mass revolving round a centre resists being put in motion, is equal to its quantity of matter multiplied by the square of its distance from its centre of motion (see article Rotation), we have $m\,y^2$ for the momentum of inertia of the machine. It is obvious that every machine opposes a certain resistance to any force that endeavours to give it an angular motion, and that this resistance will increase with the inertia of its parts. It is easy, therefore, to find a quantity of matter, which, when placed at any part of the machine, will oppose the same resistance to an angular motion, as the combined inertia of the various parts of the machine. This is the quantity of matter which we have called m, and which we have supposed to act at the working point, because to that point all the other resistances have been reduced. Collecting the symbols, therefore, we have

$x=$ the velocity of the impelled point or the radius of the wheel, or the length of the lever by which the power acts.

$y=$ the velocity of the working point, or the radius of the axle, or the length of the lever by which the resistance acts against the power.

P $=$ the pressure exerted by the power at the impelled point of the machine.

R $=$ the pressure which the resistance arising from the work to be performed exerts at the working point of the machine.

$a=$ the inertia of the power P, or the quantity of matter to which it must communicate the velocity of the impelled point.

$b=$ the inertia of the resistance R, or the quantity of matter which it must move with the velocity of the working point before any work is performed.

$\varphi=$ a quantity of matter which, if placed at the working point of the machine, would oppose the same resistance to the moving power as that which arises from the friction of the communicating parts.

$m=$ the quantity of matter which, if placed at the working point of the machine, would oppose the same resistance to the production of an angular motion, that is opposed by the inertia of the various parts of which the machine is composed. Hence, by the principles of rotation, we have

$my^2=$ the momentum of inertia of the machine.

We are now prepared for determining the conditions of construction, which will enable any machine to produce a maximum effect.

Prop. I.

308. To determine the velocities which must be given to the impelled and working points of a machine, or the ratio of the levers by which the power and resistance ought to act, in order to obtain a maximum effect.

Let AB be a lever, whose fulcrum is F, and to whose extremity B is applied to the power P to overcome the resistance R, and let FB$=x$, and FA$=y$. Then, by Art. 36. we shall have, from the following analogy, the weight which, placed at B, would be in equilibrio with R; $x : y = \text{R} : \frac{\text{R}y}{x}$, the weight which will keep R in equilibrio, or the weight which is equal to Fig. 2.

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to that part of the power P which balances the resistance R. Hence, $P-\frac{Ry}{x}$ will be the effective force exerted by the power P, which, multiplied by x, its distance from the centre of motion gives $Px-Ry$ for the force which is exerted in giving an angular motion to the power and resistance. But the resistance of friction was supposed equal to the weight φ acting at the working point or at the distance FA or y; consequently, φy will be the resistance which friction opposes to the force $Px-Ry$, and therefore $Px-Ry-\varphi y$ is the motive force exerted by P. Now, the momentum of the inertia of the power P, or the force with which it resists being put in motion, is ax^2, and the momentum of inertia of the resistance R is by^2, while the momentum of inertia of the machine is my^2. Therefore, the sum of these momenta, viz. $ax^2+by^2+my^2$ is the mass to be put in motion by the power P. But, by DYNAMICS, § 167. the velocity generated in a given time is directly as the motive force, and inversely as the quantity of matter to which that force is applied. Hence the angular velocity, or the number of turns which the machine will make in a given time, is $\frac{Px-Ry-\varphi y}{ax^2+by^2+my^2}$. But in every rotatory machine the velocities of its different parts are as their distance from the axis; hence, we shall have the velocities of the impelled and working points of the machine, by multiplying the angular velocity by x, y the distances of the impelled and working points of the machine from the centre of motion. Therefore,

$\frac{Px^2-Rxy-\varphi xy}{ax^2+by^2+my^2}=$ the velocity of the impelled point,

and

$\frac{Pxy-Ry^2-\varphi y^2}{ax^2+by^2+my^2}=$ the velocity of the working point

of the machine; and multiplying by R, we have from

Def. 4. $\frac{PxyR-R^2y^2-\varphi Ry^2}{ax^2+vy^2+my^2}=$ the work performed.

309. But as forces are proportional to the velocities generated by them in equal times (DYNAMICS, § 153. Cor. 4. § 159.), the preceding quantities will represent the accelerating forces. Now, the velocities are as the forces and times jointly (DYNAMICS, § 153.), that is, $v=Ft$, or is $=gtF$; but F, the accelerating force, which generates the velocity of the impelled point, is represented by the formula $\frac{Px^2-Rxy-\varphi xy}{ax^2+by^2+my^2}$. Therefore, v, or the absolute velocity of the impelled point, is $\frac{Px^2-Rxy-\varphi xy}{ax^2+by^2+my^2}\times gt$, and the absolute velocity of the working point $\frac{Pxy-Ry^2-\varphi y^2}{ax^2+by^2+my^2}\times gt$. Again, by Def. 4. the effect of a machine, or the work performed, is equal to the resistance of the work multiplied by the velocity; consequently, since R is the work, we have for the performance of the machine,

$$\frac{PxyR-R^2y^2-\varphi Ry^2}{ax^2+by^2+my^2}\times gt.$$

Now, considering y as the variable quantity, and making the fluxion of the preceding formula $=0$, we shall find that the performance of the machine is a maximum, when

$$y=\frac{\overline{a^2\times\overline{R+\varphi}|^2+P^2a\times\overline{m+b}}|^{\frac{1}{2}}-aR-a\varphi}{Pm+Pb}\times x.$$

When $R=0$, we have

$$y=\frac{\overline{a^2\varphi^2+P^2a\times\overline{m+b}}|^{\frac{1}{2}}-a\varphi}{Pm+Pb}\times x.$$

When $\varphi=0$, the first formula becomes

$$y=\frac{\overline{a^2R^2+P^2a\times\overline{m+b}}|^{\frac{1}{2}}-aR}{Pm+Pb}\times x.$$

When both R and $\varphi=0$, we have, after reduction,

$$y=\frac{\sqrt{a}}{\sqrt{m+b}}\times x.$$

When $b=0$, the first formula becomes

$$y=\frac{\overline{a^2\times\overline{R+\varphi}|^2+P^2am}|^{\frac{1}{2}}-aR-a\varphi}{Pm}\times x.$$

When R, φ and $b=0$, we have

$$y=\frac{\sqrt{a}}{\sqrt{m}}\times x.$$

When $a:b=P:R$, we have, by substituting P and R instead of a and b,

$$y=\frac{\overline{P^2\times\overline{R+\varphi}|^2+P^3\times\overline{m+R}}|^{\frac{1}{2}}-PR-P\varphi}{Pm+PR}\times x.$$

When Pm and $\varphi=0$, the last formula becomes

$$y=\frac{\overline{P^2R^2+P^3R}|^{\frac{1}{2}}-PR}{PR}\times x=\sqrt{\frac{P^2R^2+P^3R}{P^2R^2}}-\frac{PR}{PR}\times x.$$

$$x=\sqrt{\frac{P}{R}+1}\Big|-1,$$

and when $x=1$, and $R=1$, we have

$$y=\sqrt{P+1}\Big|-1,$$

and when $P=1$, and $x=1$, we obtain

$$y=\sqrt{\frac{1}{R}+1}\Big|-1.$$

When $x=1$,

$$y=\sqrt{\frac{P}{R}+1}\Big|-1.$$

These various formulæ, the application of which to particular cases shall be shown in the practical part of this article, give us values of y for almost every species of machinery; so that the mechanic may easily determine the velocities which must be given to the impelled and working points of the machine in order to produce a maximum effect.

310. When the machine, however, is already constructed, the velocities of the impelled and working points cannot be changed, without altering the structure of the machine; and therefore we must find the ratio between the power and resistance, which will enable

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enable us to obtain a maximum effect. The method of determining this will be shewn in the following proposition.

Prop. II.

311. To determine the ratio between the power and the resistance of a machine when its performance is a maximum.

Since the structure of the machine is given, the values of x, y are known, and therefore we have to determine the relative values of P and R, when the effect of the machine is a maximum. This would be easily done, by making R variable in the formula which expresses the performance of the machine, and making its fluxion equal to 0, if none of the other quantities varied along with R. It often happens, however, that while R varies, the mass b suffers a considerable change, though in other cases the change induced upon b is too unimportant to merit notice. This proposition, therefore, admits of two cases, 1. When the change upon b is so small that it may be safely omitted in the investigation; and, 2. When the change upon b is sufficiently great to require attention.

312. Case 1. When R is the only quantity which is variable, the fluxion of the formula

$$\frac{\mathrm{P}\,x\,y\,\mathrm{R}-\mathrm{R}^2y^2-\varphi\,\mathrm{R}\,y^2}{a\,x^2+b\,y^2+m\,y^2}$$

which represents the work performed, is equal to the fluxion of the numerator, because the denominator is constant, that is, $\mathrm{P}\,x\,y\,\dot{\mathrm{R}}-2\,\mathrm{R}\dot{\mathrm{R}}\,y^2-\varphi\,\dot{\mathrm{R}}\,y^2=0$, and, dividing by $\dot{\mathrm{R}}$; $\mathrm{P}\,xy-2\,\mathrm{R}\,y^2-\varphi\,y^2=0$, hence $2\,\mathrm{R}\,y^2=\mathrm{P}\,xy-\varphi\,y^2$, and $\mathrm{R}=\frac{\mathrm{P}\,xy-\varphi\,y^2}{2\,y^2}$, which, divided by y, gives $\mathrm{R}=\frac{\mathrm{P}\,x-\varphi\,y}{2\,y}$. Now, according to the experiments of Coulomb, the friction is, in general, proportional to the resisting pressure, or a certain part of that pressure, for example, $\frac{1}{15}\mathrm{R}$; and calling $\mathrm{Z}=\frac{1}{15}$, and omitting $\varphi\,y$, we have for the resistance $\mathrm{R}+\frac{1}{15}\mathrm{R}$, or $\frac{16}{15}\mathrm{R}=\frac{\mathrm{P}\,x-\varphi}{2\,y}$, or $\mathrm{R}=\left(\frac{\mathrm{P}x}{2\,y}\right)\div\frac{16}{15}$, and making $\mathrm{P}=1$, and $x=1$, we have $\mathrm{R}=\left(\frac{1}{2y}\right)\div\frac{16}{15}$, so that abstracting from the quotient $\frac{16}{15}$, which being little greater than 1, will not alter the result, the resistance should be one-half of the force which would keep the impelling power in equilibrio.

313. Case 2. When b varies at the same time with R, it will in most cases vary in the same proportions, and therefore may be represented by any multiple of R, as d R, where d may be either an integer or a fraction. In order to simplify the investigation, we may consider the fraction φ as a resistance diminishing the impelling power, instead of regarding it as a resistance to be added to the other resisting forces. Thus the impelling power P will become $\mathrm{P}-\varphi$. In the same way we may consider the momentum of the machine's inertia applied to the impelled point, that is, instead of my^2 it may be made $m\,x^2$. Now making $\mathrm{P}-\varphi$, or the impelling power $=1$, and making $x=1$, we shall have by these substitutions in the formula which expresses the effect of the machine, $\frac{\mathrm{R}\,y-\mathrm{R}^2y^2}{a+m+d\mathrm{R}\,y^2}$, or, for the sake of simplicity, making $a+m=q$, we have for the performance of the machine $\frac{\mathrm{R}y-\mathrm{R}^2y^2}{q+dry^2}$; then since R is the variable quantity, we shall find, after making the fluxion of this formula $=0$, that the performance is a maximum when $\mathrm{R}=\frac{\overline{q^2+q\,dy}|^{\frac{1}{2}}-q}{d\,y^2}$.

When $b=\mathrm{R}$ then $d-1$, and we shall have

$$\mathrm{R}=\frac{\overline{q^2+qy}|^{\frac{1}{2}}-q}{y^2}.$$

When $a=\mathrm{P}$ and $\mathrm{P}=1$, and when m, the inertia of the machine, $=0$, we shall have $a+m=1=q$, and then the formula becomes

$$\mathrm{R}=\frac{\overline{y+1}|^{\frac{1}{2}}-1}{y^2}.$$

When $y=x$, then $y=1$, and

$$\mathrm{R}=\frac{\overline{1+1}|^{\frac{1}{2}}-1}{1}=0.4142.$$

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314. Those who wish to prosecute this interesting subject may consult the different papers of Euler in the *Comment. Petropol.* vol. x. p. 80, 1743, and in the *Comment. Nov. Petropol.* vol. iii. and viii. In the article Machinery in the Supplement to the last edition of this Work, the subject has been treated with great ability by Dr Robison, though he has omitted the various steps in the investigation which conduct to the leading formulæ. The subject has been also ably discussed by Professor Leslie in a paper published in the Appendix to Ferguson's Lectures, vol. ii. p. 353; and as the results of his investigations may be of great use in practice, we shall here present the reader with a short abstract of them.

If the resistance is equal to the power, is double, triple, or quadruple, &c. a maximum effect will be produced when the velocity of the power, or its distance from the centre of motion, is $1+\sqrt{2}$; $2+\sqrt{6}$; $3+\sqrt{12}$; $4-\sqrt{20}$; $5+\sqrt{30}$; $6+\sqrt{42}$, that of the weight being 1, &c. If the resistance is very great, compared with the power, the velocity should at least be double of that which would procure an equilibrium, in order that the machine will produce a maximum effect.

315. If the velocity of the power, or its distance from the centre of motion, be equal to, double, triple, quadruple, &c. &c. of the velocity of the weight or resistance, a maximum effect will be produced when the power P is equal to $\mathrm{R}\times\overline{1+\sqrt{2}}$; $\mathrm{R}\times\overline{\frac{1}{2}+\sqrt{\frac{3}{8}}}$; $\mathrm{R}\times\overline{\frac{1}{3}+\sqrt{\frac{4}{27}}}$; $\mathrm{R}\times\frac{1}{4}+\sqrt{\frac{5}{64}}$, $\mathrm{R}\times\frac{1}{5}+\sqrt{\frac{6}{125}}$, &c. where R is the resistance or weight to be raised. If the velocity of the power be very large, a maximum effect will be produced when the power B is, at least, double of that which would procure an equilibrium. It appears also from Mr Leslie's paper, that in whatever way the maximum be procured, the force which impells the

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the weight can never amount to one-fourth part of the direct action of the power; and that in machines where the velocity of the power is great, we may disregard the momenta of the connecting parts, and consider the force which ought to be employed as double of what is barely able to maintain the equilibrium.

Chap. VIII. *On the Equilibrium of Arches, Piers, and Domes.*

Fig. 3. 316. Def. 1. An arch is represented in fig. 3. by the assemblage of stones *a b*, *c d*, *c f*, &c. forming the mass ABMN, whose inferior surface is the portion of a curve. The parts A, B are called the *spring of the arch*, the line AB the *span of the arch*, C *b* its *altitude*, *b* its crown, *a b* the *keystone*, the curve or lower surface A *b* B the *intrados*, and the roadway TUV the *extrados;* PQ, RS, the *piers* when they stand between two arches, and the *abutments* when they are at the extremities of the bridge.

Fig. 4. 317. Def. 2. A catenarian curve is the curve formed by any line or cord perfectly flexible, and suspended by its extremities. Thus if the chain ACB be suspended by its extremities A, B, it will by the action of gravity upon all its parts assume the form ACB, which is called the catenary or catenarian curve.

318. There are three modes of determining the construction of arches; the first of which is to consider the arch as an inverted catenary; the second is to establish an equilibrium between the vertical pressures of all the materials between the intrados and extrados; and the third is to regard the different arch-stones as portions of wedges without friction, which endeavour by their own weight to force their way through the arch. The first of these methods was given by the ingenious Dr Hook, and is contained in the following proposition.

Prop. I.

319. To determine the form of an arch by considering it as an inverted catenary, when its span, its altitude, and the form of the roadway or extrados are given.

Fig. 5. Let *a*, *b*, *c*, *d* be a number of spheres or beads connected by a string, and suspended by their extremities A, B; they will form a catenarian curve A *a b c* B, and be in equilibrio by the action of gravity. Each sphere is acted upon by two forces; at its lower point by the weight of the spheres immediately below it, and at its upper point by the weight of the same spheres added to that of the sphere itself; that is, any sphere *c* is in equilibrio from the result of two forces, one of which is produced by the weights of *c d e* acting at the lower point of *b*, while the other force arises from the weight of *b c d e* acting at its upper point. The equilibrium of this chain of spheres is evidently of the stable kind, as it will immediately recover its position when the equilibrium is disturbed. Let us now suppose this arch inverted, so as to stand in a vertical plane as in

Fig. 6. fig. 6. It will still preserve its equilibrium. For the relative positions of the lines which mark the directions remain unchanged by inverting the curve, the force of gravity continues the same, and therefore the result of these forces will be the same, and the arch will be in equilibrio. The equilibrium, however, which the arch now possesses is of the tottering kind, so that the least disturbing force will destroy it, and it will consequently be unable to support any other weight but its own.

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320. Let us now suppose that it is required to form an equilibrated arch, whose span is AB, whose altitude is D *k*, and which will support the materials of a roadway, whose form TUV is given. It is obvious, that if the spheres *a*, *b*, *c*, *d* increase in density from *k* towards *a*, the catenarian curve will grow less concave at its vertex *c*, and more concave towards its extremities A, B. Let us then suppose that the densities of the spheres *a*, *b*, *c*, *d*, *e*, &c. are respectively as *a m*, *b n*, *c o*, *d p*, *e q*, &c. the vertical distances of their respective centres from the roadway TUV, the arch will have a form different from that which it would have assumed if the spheres were of equal density, and will be in equilibrio when inverted as in fig. 6. Now, in place of the Fig. 6. spheres *a*, *b*, *c*, *d*, *e*, &c. of different densities, let us substitute spheres of the same density, and having the same position as those of different densities; let us then load the sphere *a* with a weight which, when combined with the weight of *a*, will be equal to the weight of the corresponding sphere *a*, that had a greater density; and let us load the other spheres *b*, *c*, *d*, &c. with weights proportional to *b n*, *c o*, *d p*, &c. Then it is obvious that the pressure of each sphere when thus loaded upon that which is contiguous to it, is precisely equal to the pressure of the spheres of different densities upon each other, because the density of these spheres varied as their distances from the roadway. But the arch composed of spheres of different densities was in equilibrio when inverted, therefore since the loaded spheres of the same density have the same position and exert the same pressures, the arch composed of these spheres and supporting TUVB *k* A composed of homogeneous materials will be in equilibrio. *Hence a roadway of a given form, and composed of homogeneous materials, will be supported by an arch whose form is that of a catenary, each of whose points varies in density as their distance from the surface of the roadway;* or, which is the same thing, *A roadway of a given form, and composed of homogeneous materials, will be supported by an arch whose form is that of a catenary, each of whose points is acted upon by forces proportional to the distances of these points from the surface of the roadway.*

321. Hence we have the following practical method of ascertaining the form of an equilibrated arch, whose span is AB, and altitude D *k*, and which is to support a roadway of the form T′U′V′. Let a chain Fig. 7. A *a b c k* B, of uniform density, be suspended from the points A, B, so that it forms a catenary whose altitude is D *k*, the required height of the arch. Divide AB into any number of equal parts, suppose eight, and let the vertical lines 1 *m*, 2 *n*, 3 *o*, drawn from these points, intersect the catenary in the points *a*, *b*, *c*. From the points *a*, *b*, *c*, *k*, *r*, *s*, *t*, suspend pieces of chain of uniform density, and form them of such a length, that when the whole is in equilibrio, the extremities of the chains may lie in the line T′U′V′; then the form which the catenary A *k* B now assumes, will be the form of an equilibrated arch, which, when inverted like AKB, will support the roadway TUV, similar to T′U′V′. This

Theory. This is obvious from the last paragraph, for the pieces of chain $a\,m$, $b\,n$, $c\,o$, k U, &c. are forces acting upon the points a, b, c, k of the catenary, and are proportional to $a\,m$, b, n, c, o, &c. the distances of the points a, b, c, k, &c. from the roadway.

322. An arch of this construction will evidently answer for a bridge, in which the weight of the materials between the roadway and the arch stones is to the weight of the arch stones, as the weight of all the pieces of chain suspended from a, b, c, &c. is to the weight of the chain A k B. As the ratio, however, of the weight of the arch stones to the weight of the superincumbent materials is not known, we may assume a convenient thickness for the arch stones, and if from this assumed thickness their weight be computed, and be found to have the required ratio to the weight of the incumbent mass, the curve already found will be a proper form for the arch. But if the ratio is different from that of the weight of the whole chain to the weight of the suspended chains; it may easily be computed how much must be added to or subtracted from the pieces of chain, in order to make the ratios equal. The new curve which the catenary then assumes, in consequence of the change upon the length of the suspended chains, will be the form of an equilibrated arch, the weight of whose arch stones is equal to that which we assumed.

Scholium.

323. In most cases the catenarian curve thus determined will approach very near to a circular arc equal to 120 degrees, which springs from the piers so as to form an angle of 60 degrees with the horizon. The form of the arch, however, as determined in the preceding proposition, is suited only to those cases in which the superincumbent materials exert a vertical pressure. A quantity of loose earth and gravel exerts a pressure in almost every direction, and therefore tends to destroy the equilibrium of a catenarian arch. This tendency, however, may be removed by giving the arch a greater curvature towards the piers. This will make it approach to the form of an ellipsis, and make it spring more vertically from the piers or abutments.

324. We shall now proceed to deduce the form of an arch and its roadway, by establishing an equilibrium among the weights of all the materials between the arch and the roadway. This method was given by Emerson in his Fluxions, published in 1742, and afterwards by Dr Hutton in his excellent work on bridges.

Prop. II.

325. To determine the form of the roadway or extrados, when the form of the arch or intrados is given.

Fig. 8. Let the lines AD, DE, EB, BF, FG, GH lie in the same plane, and let them be placed perpendicular to the horizon. From the points D, E, B, &c. draw the vertical lines D d, E e, B b, &c. and taking D p of any length, make E r equal to D p, &c. and complete the parallelograms $p\,c$, $q\,r$. Again, make B s=$q\,e$, and complete the parallelogram ts; in like manner make F k=sb, and complete the parallelogram F f; and so on with all the other lines, making the side of each parallelogram equal to that side of the preceding parallelogram which is parallel to it. Let us now suppose that the lines CD, DE, EB, &c. can move round the angular points D, E, B, F, &c. the extremities A, C being immoveable; and that forces proportional to Dd, Ee, Bb, &c. are exerted upon the points D, E, B, F, &c. and in the direction D d, E e, &c. Now, by the resolution of forces, the force D d may be resolved into the forces D c, D p, the force E e into the forces E q, E r, and the force B b into the forces B s, B t, and so on with the rest. The force D c produces no other effect than to press the point A on the plane on which it rests, and is therefore destroyed by the resistance of that plane; but the remaining force Dp tends to bring the point D towards E, and to enlarge the angle ADE; this force, however, is destroyed by the equal and opposite force E q, and in the same way the forces E r, B t, F x are destroyed by the equal and opposite forces Bs, Fk, Gv, while the remaining force G w is destroyed by the resistance of the plane which supports the point C. When the lines AD, DE, &c. therefore are acted upon by vertical forces proportional to D d, E e, B b, &c. these forces are all destroyed by equal and opposite ones, and the lines will remain in equilibrio. Theory.

326. Now the force D c : Dp or E q=sin. $e\,d$ D or d Dp : sin. AD d, that is, by taking the reciprocals

$$\mathrm{D}\,c : \mathrm{E}\,q = \frac{1}{\sin.\ \mathrm{AD}d} : \frac{1}{\sin.\ d\ \mathrm{D}p},$$

and for the same reason

$$\mathrm{E}\,q : \mathrm{B}\,s = \frac{1}{\sin.\ \mathrm{E}\,e\,q} : \frac{1}{\sin.\ b\,\mathrm{B}\,s}.$$

Hence

$$\mathrm{E}\,q \doteq \frac{1}{\sin.\ \mathrm{E}\,e\,q}.$$

Now, since E q : E e=sin. E $e\,q$: sin. E $q\,e$, we have $\mathrm{E}\,e = \frac{\mathrm{E}\,q \times \sin.\ \mathrm{E}\,q\,e}{\sin.\ \mathrm{E}\,e\,q}$, that is, since DE$m$=E $q\,e$, and eEB=E $e\,q$; $\mathrm{E}\,e = \frac{\mathrm{E}\,q \times \sin.\ \mathrm{DE}m}{\sin.\ e\ \mathrm{EB}}$. But $\mathrm{E}q \doteq \frac{1}{\sin.\ \mathrm{E}eq}$ therefore, by substitution, we obtain

$$\mathrm{E}\,e \doteq \frac{\sin.\ \mathrm{DE}m}{\sin.\ \mathrm{E}eq \times \sin.\ e\ \mathrm{EB}}.$$

Now, as the same reasoning may be employed to find D d, B b, &c. we have obtained expressions of the forces which, when acting at the angular points D, E, B, &c. keep the whole in equilibrio, and these expressions are in terms of the angles which the lines DE, EB, &c. form with the direction of the forces. If the lines AD, DE, &c. be increased in number so that they may form a polygon with an infinite number of sides, which will not differ from a curve line, then the forces will act at every point of the curve, and the line m E will be a tangent to the curve at the point E, and DE m will be the angle of contact. The line E q being now infinitely small will coincide with E m, and therefore the angles c E q and e EB or E $e\,q$ will be equal to the angle e E m, and consequently their sines will be equal. Therefore by making these substitutions in the last formula, we have an expression of the force at every point of the curve, thus

$$\mathrm{E}\,e \doteq \frac{\sin.\ \mathrm{DE}\,m}{\sin.\ e\,\mathrm{E}\,m \times \sin.\ e\,\mathrm{E}m} \doteq \frac{\sin.\ \mathrm{DE}\ m}{\sin.\ e\ \mathrm{E}\,m|^2}.$$

But

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But the angle of contact DE m varies with the curvature at the point E, and the curvature varies as the reciprocal of the radius of curvature, therefore the angle of contact varies as the reciprocal of the radius of curvature; hence by substitution,

$$\mathrm{E}e \doteq \frac{1}{\text{radius of curvature} \times \overline{\sin.\, e\mathrm{E}m}^2}.$$

Fig. 9. In order to get rid of the confusion in fig. 8. where the arch is a polygon, let us suppose ABC, fig. 9. to be the curve mn a tangent to any point E, and Ee a vertical line; *then the pressure at any point of the arch is reciprocally as the radius of curvature at that point, and the square of the sine of the angle which the tangent to that point of the curve forms with a vertical line.*

327. COROLLARY. Let us now suppose that the arch ABC supports a mass of homogeneous materials lying between the roadway TUV and the arch AEBC; and the whole being supposed in equilibrio, let us determine the weight which presses on the point E. The weight of the superincumbent column Ecbd varies as E$c\times gd$, but gd=E$d\times$sin. dEg, Ed being radius, and dEg =EnB, on account of the parallels Ec, UB, therefore the weight of the column Ecbd varies as E$c\times$ E$d\times$sin. EnB, that is, as E$c\times$sin. EnB, because Ed is a constant quantity; but the pressure at E was proved to vary as $\frac{1}{\text{radius curvature}\times\overline{\sin.\, e\mathrm{E}m}^2}$, therefore the weight of the column Ecbd or E$c\times$sin. EnB varies also as this quantity, that is,

$$\mathrm{E}c\times\sin.\,\mathrm{E}n\mathrm{B} \doteq \frac{1}{\text{radius curvature}\times\overline{\sin.\, e\mathrm{E}m}^2}.$$

But as the angle EnB is equal to the angle eEm, we shall have, by substitution and division,

$$\mathrm{E}c \doteq \frac{1}{\text{radius curvature}\times\overline{\sin.\, e\mathrm{E}m}|^3},$$ that is,

When an arch supports a roadway, the pressure exerted upon any point of it, is reciprocally as the radius of curvature, and the cube of the sine of the angle which the tangent to that point forms with a vertical line.

328. Having thus obtained an expression for Ec, we shall proceed to shew the application of the formula to the case when the arch is a portion of a circle.

Fig. 10. Let EB be the arch of a circle whose centre is F. Let the radius = R, BD = versed sine, BE=x, DF=cos. BE=b, BU=m. Draw the tangent GE, and through E the vertical line cc, which will be parallel to BE. Then since GEF is a right angle, and eEF=EFB, the angle GEe is the complement of EFB, therefore, sin. GEe=cos. EFB=FD. But, in the present case, the radius of curvature is the radius of the arch, or R, therefore, E$c \doteq \frac{1}{\mathrm{R}\times\overline{\sin.\,\mathrm{GE}e}}$, or by substitution, E$c \doteq \frac{1}{\mathrm{R}\,b^3}$, that is, since R is constant, E$c \doteq \frac{1}{b^3}$. But when the point E coincides with B, the cosine b becomes equal to radius; therefore, in that case E$e \doteq \frac{1}{\mathrm{R}^3}$, and E$c$ becomes BU $= m$, hence $\frac{1}{\mathrm{R}^3} : \frac{1}{b^3} = m :$ Ec, and by GEOMETRY, Theor. 8. Sect. IV. and Division, we have E$c=\frac{m\,b^3}{b^3}$. Now, by the notation R : b=BF : DF; therefore R³ : b^3 $=\overline{\mathrm{BF}^3}$: DF³, hence $\frac{\mathrm{R}^3}{b^3}=\frac{\overline{\mathrm{BF}^3}}{\mathrm{DF}^3}$, and multiplying each side by m, we have $\frac{m\,\mathrm{R}^3}{b^3}=\frac{m\,\overline{\mathrm{BF}^3}}{\mathrm{DF}^3}$; but $\frac{m\,\mathrm{R}^3}{b^3}=Ec$, therefore the vertical distance of the surface of the roadway from the point F, or E$c=\frac{m\,\overline{\mathrm{BF}^3}}{\mathrm{DF}^3}=\frac{\mathrm{BU}\times\overline{\mathrm{BF}^3}}{\mathrm{DF}^3}$.

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When the point E coincides with B, BF=DF, and Ec=BU. When E coincides with A, the cosine DF vanishes, and therefore Ec, or the distance of the point A from the extrados or roadway, is infinite. The curve VUcT, therefore, will run up to an infinite height, approaching continually to a vertical line, drawn from A, which will be its asymptote. Such a form of the extrados, however, is inadmissible in practice; and therefore a semicircular arch is not an arch of equilibration. When the arch is less than a semicircle, as PBR, the curve terminates in the point p; and as it does not rise very much above a horizontal line, passing through U when the arch is small, we might produce a perfect equilibrium, by making the roadway horizontal as tUv, and making the density of the superincumbent columns Pn, Eo, which press upon the points P, E respectively, in the ratio of Pp, Ec, the distances of these points from the curvilineal roadway.

329. The inconvenience, however, arising from the inflexion of the extrados, may be considerably removed by throwing the point of contrary flexure to a greater distance, which may be done by diminishing BU, the thickness of the incumbent mass above the keystone. Thus, if BU is diminished to Bd, and if points a, b are taken in the lines Pp, Ec, so that Pa : Pp=Eb : Ec=Bd : BU, and so on with all the points in the arch; and if a new roadway $vdbat$ be drawn through these points, the equilibrium of the arch will still continue, for the various pressures which it sustained, though they are diminished, preserve the same proportion.

330. Let us suppose it necessary to have the extrados a horizontal line, and let it be required to find BU=m when there is an equilibrium. In this case the point H coincides with U; or rather, when the curve UcT cuts the horizontal line tUv, the point H coincides with U. By substituting BF—BD instead of DF in the value of Ec, formerly determined, and by putting BD=y, we have E$c=\frac{m\,\mathrm{R}^3}{\overline{\mathrm{R}-y}|^3}$. But when H coincides with U, c coincides with o, and therefore Eo=Ec=BD+BU $=y+m$, consequently, $\frac{m\,\mathrm{R}^3}{\overline{\mathrm{R}-y}|^3}=y+m$, and multiplying by $\overline{\mathrm{R}-y}|^3$, we have $m\mathrm{R}^3=y\times\overline{\mathrm{R}-y}|^3+m\times\overline{\mathrm{R}-y}|^3$, or $m\,\mathrm{R}^3+m\times\overline{\mathrm{R}-y}|^3=y\times\overline{\mathrm{R}-y}|^3$, and, dividing by the coefficients of m, we have

$$m=\frac{y\times\overline{\mathrm{R}-y}|^3}{\mathrm{R}^3-\overline{\mathrm{R}-y}|^3},$$ that is,

The thickness of the roadway above the keystone, when the extrados is a straight line, is equal to the quotient arising

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arising from multiplying the versed sine of half the arch by the cube of its cosine, and dividing this product by the difference between the cube of the radius, and the cube of the cosine; or, to change the expressions, *the thickness of the roadway above the keystone, when the roadway is a straight line, is equal to the quotient arising from multiplying the height of the arch, by the cube of the difference between the radius of the arch and its height, and dividing this product by the difference between the cube of the radius, and the cube of the difference between the radius and the height of the arch.*

331. When the arch is a semicircle $R-y$ vanishes, and m becomes equal 0, so that the semicircular arch is evidently inadmissible. But when the arch is less than a semicircle, the value of m will be finite. Thus, if the arches are respectively

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60°, we have $m=\frac{1}{4}$ the span,
90°, we have $m=\frac{1}{2}$ of the span, or
110°, we have $m=\frac{1}{17}$ of the span nearly.

The two first arches of 60° and 90°, manifestly give too great a thickness to the part BU or m. In the third arch of 110°, the thickness of BD is nearly what is given to it by good architects, and is therefore the best in practice; for if the arch were made greater than 110°, the thickness of BU or m would be too small. It is obvious, however, that an arch of 110° is not an arch of *perfect* equilibration, for this can be the case only when the roadway has the form U z r. When the roadway, therefore, is horizontal, as U r, there is an unbalanced pressure on both sides of the keystone, produced by the weight of the materials in the mixtilinear space r z U. It is indeed very small, and might be counteracted, by making the materials below R lighter than those below U: but the unbalanced pressure is so trifling, that it may be safely neglected. We may, therefore, conclude, *that when the arch is to be circular with a horizontal roadway, an arch of 110 degrees approaches nearest to an arch of equilibration.*

Elliptical arches superior to circular arches when their transverse axis is horizontal.

332. When the arch is elliptical, it will be found, as in the circle, that $m=\frac{y\times\overline{R-y}|^3}{R^3-\overline{R-y}^3}$. An elliptical arch, however, has the advantage of a circular one, when the transverse axis is horizontal; for as it is much flatter, the point of contrary flexure in the extrados is thrown at a greater distance, and therefore it will, with less inconvenience, admit of a horizontal roadway. Elliptical arches have also the advantage of being more elegant, and likewise require less labour and materials.

333. The cycloidal arch is likewise superior to a circular one, but inferior to those which are elliptical. Parabolic, hyperbolic, and catenarian arches, may be employed when the bridge has only one arch, and is to rise high; but in other cases they are inadmissible. The method of determining the roadway for all these forms of arches will be found in Dr Hutton's excellent work on the Principles of Bridges, p. 3. See also Emerson's Miscellanies, p. 156.; and his work on Fluxions, published in 1742.

On the mechanical curve of equilibration.

334. When the form of the roadway is given, the shape of the intrados for an arch of equilibration may be determined. As the investigation is very difficult, unless when the roadway is a horizontal line, we shall merely give the formula, which will enable any person to construct the curve. In all other curves the equilibrium of the arch is imperfect; but the curve described by the following formula is an arch of perfect equilibration, and has been called *the mechanical curve of equilibration.*

$$ED=AF\times\frac{\text{Hyperbol. log.}\ \dfrac{BU+BD+\sqrt{2\,BU\times BD+\overline{BD}^2}}{BU}}{\text{Hyperbol. log.}\ \dfrac{BU+BF+\sqrt{2\,BU\times BF+\overline{BF}^2}}{BU}}$$

From this formula, which corresponds with figure 11. Dr Hutton has computed the following table, containing the values of c U and c E, for an arch whose span AC is 100, whose height BF is 40, and whose thickness at the crown or BU is 6. The table will answer for any other arch whose span and thickness are as the numbers 100, 40, 6; only the values of c U and c E must be increased or diminished in the same ratio as these numbers.

Table for constructing the Curve of Equilibration, when the span, height, and thickness at the crown, are as the numbers 100, 40, *and* 6.

Value of cU.	Value of cE.	Value of cU.	Value of cE.	Value of cU.	Value of cE.	Value of cU.	Value of cE.	Value of cU.	Value of cE.
0	6.000	15	8.120	24	11.911	33	18.627	42	29.919
2	6.035	16	8.430	25	12.489	34	19.617	43	31.563
4	6.144	17	8.766	26	13.106	35	20.665	44	33.299
6	6.324	18	9.168	27	13.761	36	21.774	45	35.135
8	6.580	19	9.517	28	14.457	37	22.948	46	37.075
10	6.914	20	9.934	29	15.196	38	24.190	47	39.126
12	7.330	21	10.381	30	15.980	39	25.505	48	41.293
13	7.571	22	10.858	31	16.811	40	26.894	49	43.581
14	7.834	23	11.368	32	17.693	41	28.364	50	46.000

335. The

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335. The construction of arches has also been deduced from considering the arch-stones as frustums of polished wedges without friction, which endeavour to force their way through the arch. This principle has been adopted by Belidor, Parent, Bossut, Prony, and other French philosophers, and likewise by our ingenious countryman, the late Mr Atwood. This theory, however, is more plausible than useful. So far from the arch-stones having liberty to slide between those which are contiguous to them, without friction, they are bound together by the strongest cement, and sometimes connected by iron pins or wedges. The theory likewise requires, that the weight of the arch must regularly increase as the portion of the vertical tangent cut off by lines drawn from a given point in a direction parallel to that of the joints, and therefore either the density or the magnitude of the arch-stones must be very great at the spring of the arch, where the portion of the vertical tangent is a maximum. Those who wish to be acquainted with the mode of investigation, by which the equilibrium of arches is established in this theory, may consult Prony's *Architecture Hydraulique*, tom. i. p. 152.

On the Construction of Piers and Abutments.

336. In the construction of piers and abutments, there are two circumstances which claim our attention. 1. The strength that must be given to them, in order to resist the lateral thurst which they sustain from the adjacent semiarches, and which tend either to overset them, or make them slide upon their base. 2. The form which must be given to their extremities, so that the force of the current may be a minimum.—The adhesion of the pier to the place on which it rests is always much greater than one-third of the pressure; and as the lateral thrust of the arch which this adhesion resists, is oblique to the horizon, and may be resolved into two forces, one of which is horizontal, and the other vertical, we have the vertical portion of the lateral thrust, the weight of the pier, and the friction on its base, combined in resisting the horizontal portion of the lateral thrust, which tends to make the pier slide upon its base, so that there is no danger of the pier yielding to such a pressure. We do not here consider, that the lateral thrust which tends to give a horizontal motion to the pier, is completely counteracted by the lateral thrust of the opposite semiarch, because it is necessary that the pier should have sufficient stability to resist the lateral thrust of one semiarch, in case of the failure of the opposite one. Let us therefore consider the strength of the pier which will prevent it from being overset.

337. For this purpose, let ABC be an arch, MHTO the pier, and BUHA the loaded semiarch, whose pressure tends to overturn the pier. Let G be the centre of gravity of the mass BUHA: Join GA, and from G draw GK perpendicular to AC. Then, since the whole pressure of the arch is exerted at its spring A; and since this pressure is the same as if the whole weight of the arch were collected into the point G, GA will be the direction in which the weight of the arch and the superincumbent mass acts upon the point A. Now, by DYNAMICS, the force GA may be resolved into the two forces, GK, KA, one of which KA endeavours to give the pier a motion of rotation about the point O, while the other GK denotes the weight of the loaded arch in the direction GK. Putting W, therefore, for the weight or area of the superincumbent mass, we have $GK : KA = W : \frac{W \times KA}{GK}$, the pressure upon A. Now, as this force tends to turn the pier round O by means of the lever OA, and as ON=AM is the perpendicular from the centre of motion upon the line of direction, we have $AM \times \frac{W \times KA}{GK}$ for the force which tends to overturn the pier. Now, the force which is opposed to this is the weight of the pier MHTO collected in its centre of gravity g, which acts by the vertical lever $Om = \frac{1}{2}OM$, because g is in the centre of the rectangle TM (Art. 164.). But the weight or area of the pier may be represented by $OM \times MH$; therefore, the force which resists the lateral thrust of the loaded arch is $OM \times MH \times \frac{1}{2}OM$, or $\frac{1}{2}MH \times OM$. Now, in the case of an equilibrium between these opposing forces, we have $AM \times \frac{W \times KA}{GK} = \frac{1}{2}MH \times OM^2$, which, by reduction, becomes $OM = \sqrt{\frac{2\,AM \times W \times KA}{MH \times GK}}$. This formula gives us the breadth of the pier which is capable of balancing the lateral thrust; and therefore OM must be taken a little greater than the preceding value. In practice, OM is generally between one-fifth and one-seventh of AC, the span of the arch. The method of finding the centre of gravity G of the loaded arch, whether the arch is in perfect equilibrium or not, may be seen in Dr Hutton's work already quoted, p. 49. A very simple method of doing this is to form the part BUHA of a piece of card, and to find its centre of gravity G by the rules given in Articles 201, 202, 203. This indeed supposes all the materials to be homogeneous; but if they are of various kinds, we can load the arch made of card in a similar manner, and determine its centre of gravity as before.

338. The limits of this article will not permit us to apply the method of fluxions to the determination of the form which should be given to the ends of the pier, in order that the impulse of the current may be the least possible. The theory of the resistance of fluids, indeed, differs so widely from experiment, that such an investigation would, in this place, be of little practical utility. It may be sufficient merely to remark, that the pier should have an angular form, and that the impulse of the current will be diminished as the angle is more acute. When the ends are semicircular, the impulse of the stream is reduced to one half; and though a triangular termination of the piers reduces the impulse still more, yet semicircular ends are more pleasing to the eye, and are particularly advantageous when small vessels have occasion to pass the arch. When those vessels happen to impinge against the piers, the semicircular ends are more able to bear the shock, and do less injury to the vessel, while the additional quantity of masonry will give greater stability to the pier.

On

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On the Construction of Domes.

339. Definition. A dome, cupola, or vault, is an arched roof, either of a spherical, conoidal, or spheroidal form.

The following proposition, taken from Dr Robison's article upon this subject, in the Supplement to the late edition of the Encyclopædia Britannica, contains a very brief view of the theory of domes.

Proposition.

340. "To determine the thickness of a dome vaulting when the curve is given, or the curve when the thickness is given.

Plate CXXIII. fig. 1.

"Let B b A, figure 1. be the curve which produces the dome by revolving round the vertical axis AD. We shall suppose this curve to be drawn through the middle of all the arch-stones, and that the coursing or horizontal joints are every where perpendicular to the curve. We shall suppose (as is always the case) that the thickness KL, HI, &c. of the arch-stones is very small, in comparison with the dimensions of the arch. If we consider any portion HA h of the dome, it is plain that it presses on the course, of which HL is an arch-stone, in a direction b C perpendicular to the joint HI, or in the direction of the next superior element β b of the curve. As we proceed downwards, course after course, we see plainly that this direction must change, because the weight of each course is superadded to that of the portion above it, to complete the pressure on the course below. Through B draw the vertical line BCG, meeting β b, produced in C. We may take b c to express the pressure of all that is above it, propagated in this direction to the joint KL. We may also suppose the weight of the course HL united in b, and acting on the vertical. Let it be represented by b F. If we form the parallelogram b FGC, the diagonal b G will represent the direction and intensity of the whole pressure on the joint KL. Thus it appears that this pressure is continually changing its direction, and that the line, which will always coincide with it, must be a curve concave downwards. If this be precisely the curve of the dome, it will be an equilibrated vaulting: but so far from being the strongest form, it is the weakest, and it is the limit to an infinity of others, which are all stronger than it. This will appear evident, if we suppose that b G does not coincide with the curve A b B, but passes without it. As we suppose the arch-stones to be exceedingly thin from inside to outside, it is plain that this dome cannot stand, and that the weight of the upper part will press it down, and spring the vaulting outwards at the joint KL. But let us suppose, on the other hand, that b G falls within the curvilineal element b B. This evidently tends to push the arch-stone inward, towards the axis, and would cause it to slide in, since the joints are supposed perfectly smooth and slipping. But since this takes place equally in every stone of this course, they must all abut on each other in the vertical joints, squeezing them firmly together. Therefore, resolving the thrust b G into two, one of which is perpendicular to the joint KL, and the other parallel to it, we see that this last thrust is withstood by the vertical joints all around, and there remains only the thrust in the direction of the curve. Such a dome must therefore be firmer than an equilibrated dome, and cannot be so easily broken by overloading the upper part. When the curve is concave upwards, as in the lower part of the figure, the line b C always falls below B b, and the point C below B. When the curve is concave downwards, as in the upper part of the figure, $'b$ C$'$ passes above, or without b B. The curvature may be so abrupt, that even b' G$'$ shall pass without $'b$ B$'$, and the point G$'$ is above B$'$. It is also evident that the force which thus binds the stones of a horizontal course together, by pushing them towards the axis, will be greater in flat domes than in those that are more convex; that it will be still greater in a cone; and greater still in a curve whose convexity is turned inwards: for in this last case the line b G will deviate most remarkably from the curve. Such a dome will stand (having polished joints) if the curve springs from the base with any elevation, however small; nay, since the friction of two pieces of stone is not less than half of their mutual pressure, such a dome will stand, although the tangent to the curve at the bottom should be horizontal, provided that the horizontal thrust be double the weight of the dome, which may easily be the case if it do not rise high.

Theory.

"Thus we see that the stability of a dome depends on very different principles from that of a common arch, and is in general much greater. It differs also in another very important circumstance, viz. that it may be open in the middle: for the uppermost course, by tending equally in every part to slide in toward the axis, presses all together in the vertical joints, and acts on the next course like the key-stone of a common arch. Therefore an arch of equilibration, which is the weakest of all, may be open in the middle, and carry at top another building, such as a lantern, if its weight do not exceed that of the circular segment of the dome that is omitted. A greater load than this would indeed break the dome, by causing it to spring up in some of the lower courses; but this load may be increased if the curve is flatter than the curve of equilibration: and any load whatever, which will not crush the stones to powder, may be set on a truncate cone, or on a dome formed by a curve that is convex toward the axis; provided always that the foundation be effectually prevented from flying out, either by a hoop or by a sufficient mass of solid pier on which it is set.

"We have seen that if b G, the thrust compounded of the thrust b C, exerted by all the courses above HILK, and if the force b F, or the weight of that course, be everywhere coincident with b B, the element of the curve, we shall have an equilibrated dome; if it falls within it, we have a dome which will bear a greater load; and if it falls without it, the dome will break at the joint. We must endeavour to get analytical expressions of these conditions. Therefore draw the ordinates b δ b'', BDB$''$, C d C$''$. Let the tangents at b and b'' meet the axis in M, and make MO, MP, each equal to b c, and complete the parallelogram MONP, and draw OQ perpendicular to the axis, and produce b F, cutting the ordinates in E and e. It is plain that MN

Theory. is to MO as the weight of the arch HA h to the thrust $b\,c$ which it exerts on the joint KL (this thrust being propagated through the course of HILK); and that MQ, or its equal $b\,e$, or $\delta\,d$, may represent the weight of the half AH.

"Let AD be called x, and DB be called y. Then $b\,c = \dot{x}$, and $e\,\mathrm{C} = \dot{y}$ (because $b\,c$ is in the direction of the element $\beta\,b$). It is also plain, that if we make $\dot{y}$ constant, BC is the second fluxion of x, or $\mathrm{BC} = \ddot{x}$, and $b\,c$ and BE may be considered as equal, and taken indiscriminately for $\dot{x}$. We have also $b\,\mathrm{C} = \sqrt{\dot{x}^2+\dot{y}^2}$. Let d be the depth or thickness HI of the arch-stones. Then $d\sqrt{\dot{x}^2+\dot{y}^2}$ will represent the trapezium IIL; and since the circumference of each course increases in the proportion of the radius y, $d\,y\sqrt{\dot{x}^2+\dot{y}^2}$ will express the whole course. If $\int$ be taken to represent the sum or aggregate of the quantities annexed to it, the formula will be analogous to the fluent of a fluxion, and $\int d\,y\sqrt{\dot{x}^2+\dot{y}^2}$ will represent the whole mass, and also the weight of the vaulting, down to the joint HI. Therefore we have this proportion, $\int d\,y\sqrt{\dot{x}^2+\dot{y}^2} : d\,y\sqrt{\dot{x}^2+\dot{y}^2} = b\,e : b\,\mathrm{F}, = b\,e : \mathrm{CG}, = \delta\,d : \mathrm{CG}, = \dot{x} : \mathrm{CG}$. Therefore $\mathrm{CG} = \frac{d\,y\,\dot{x}\sqrt{\dot{x}^2+\dot{y}^2}}{\int d\,y\sqrt{\dot{x}^2+\dot{y}^2}}$

If the curvature of the dome be precisely such as puts it in equilibrium, but without any mutual pressure in the vertical joints, this value of OG must be equal to CB, or to $\ddot{x}$, the point G coinciding with B. This condition will be expressed by the equation $\frac{d\,y\,\dot{x}\sqrt{\dot{x}^2+\dot{y}^2}}{\int d\,y\sqrt{\dot{x}^2+\dot{y}^2}} = \ddot{x}$, or, more conveniently, by $\frac{d\,y\sqrt{\dot{x}^2+\dot{y}^2}}{\int d\,y\sqrt{\dot{x}^2+\dot{y}^2}} = \frac{\ddot{x}}{\dot{x}}$. But this form gives only a tottering equilibrium, independent of the friction of the joints and the cohesion of the cement. An equilibrium, accompanied by some firm stability, produced by the mutual pressure of the vertical joints, may be expressed by the formula $\frac{d\,y\sqrt{\dot{x}^2+\dot{y}^2}}{\int d\,y\sqrt{\dot{x}^2+\dot{y}^2}} > \frac{\ddot{x}}{\dot{x}}$, or by $\frac{d\,y\sqrt{\dot{x}^2+\dot{y}^2}}{\int d\,y\sqrt{\dot{x}^2+y^2}} = \frac{\ddot{x}}{\dot{x}} + \frac{\dot{t}}{t}$, where t is some variable positive quantity, which increases when x increases. This last equation will also express the equilibrated dome, if t be a constant quantity, because in this case $\frac{\dot{t}}{t}$ is $= o$.

"Since a firm stability requires that $\frac{d\,y\,\dot{x}\sqrt{\dot{x}^2+\dot{y}^2}}{\int d\,y\sqrt{\dot{x}^2=\dot{y}^2}}$ shall be greater than $\ddot{x}$, and CG must be greater than CB: Hence we learn, that figures of too great curvature, whose sides descend too rapidly, are improper. Also, since stability requires that we have $\frac{d\,y\,\dot{x}\sqrt{\dot{x}^2+\dot{y}^2}}{\ddot{x}}$ greater than $\int d\,y\sqrt{\dot{x}^2+\dot{y}^2}$, we learn Theory. that the upper part of the dome must not be made very heavy. This, by diminishing the proportion of b F to b C, diminishes the angle $c\,b$ G, and may set the point G above B, which will infallibly spring the dome in that place. We see here also, that the algebraic analysis expresses that peculiarity of dome-vaulting, that the weight of the upper part may even be suppressed.

"The fluent of the equation $\frac{d\,y\sqrt{\dot{x}^2+\dot{y}^2}}{\int d\,y\sqrt{\dot{x}^2+\dot{y}^2}} = \frac{\ddot{x}}{\dot{x}} + \frac{\dot{t}}{t}$ is most easily found. It is $\mathrm{L}\int d\,y\sqrt{\dot{x}^2+\dot{y}^2} = \mathrm{L}\,\dot{x} + \mathrm{L}\,t$, where L is the hyperbolic logarithm of the quantity annexed to it. If we consider $\dot{y}$ as constant, and correct the fluent so as to make it nothing at the vertex, it may be expressed thus, $\mathrm{L}\int d\,y\sqrt{\dot{x}^2+\dot{y}^2} - \mathrm{L}\,a = \mathrm{L}\,\dot{x} - \mathrm{L}\,\dot{y} + \mathrm{L}\,t$. This gives us $\mathrm{L}\int\frac{d\,y\sqrt{\dot{x}^2+\dot{y}^2}}{a} = \mathrm{L}\frac{\dot{x}}{\dot{y}}t$, and therefore $\int\frac{d\,y\sqrt{\dot{x}^2+\dot{y}^2}}{a} = \frac{\dot{x}}{\dot{y}}$.

"This last equation will easily give us the depth of vaulting, or thickness d of the arch, when the curve is given. For its fluxion is $\frac{d\,y\sqrt{\dot{x}^2+\dot{y}^2}}{a} = \frac{\dot{t}\,\dot{x} + t\,\ddot{x}}{\dot{y}}$, and $d = \frac{a\,\dot{t}\,\dot{x} + a\,t\,\ddot{x}}{y\,\dot{y}\sqrt{\dot{x}^2+\dot{y}^2}}$, which is all expressed in known quantities; for we may put in place of t any power or function of x or of y, and thus convert the expression into another, which will still be applicable to all sorts of curves.

"Instead of the second member $\frac{\ddot{x}}{\dot{x}} + \frac{\dot{t}}{t}$ we might employ $\frac{p\,\ddot{x}}{\dot{x}}$, where p is some number greater than unity. This will evidently give a dome having stability; because the original formula $\frac{d\,y\,\dot{x}\sqrt{\dot{x}^2+\dot{y}^2}}{\int d\,y\sqrt{\dot{x}^2+\dot{y}^2}}$ will then be greater than $\ddot{x}$. This will give $d = \frac{p\,a\,\dot{x}^{p-1}\,\ddot{x}}{y\,\dot{y}^p\sqrt{\dot{x}^2+\dot{y}^2}}$. Each of these forms has its advantages when applied to particular cases. Each of them also gives $d = \frac{a\,\ddot{x}}{y\,\dot{y}\sqrt{\dot{x}^2+\dot{y}^2}}$ when the curvature is such as is in precise equilibrium. And, lastly, if d be constant, that is, if the vaulting be of uniform thickness, we obtain the form of the curve, because then the relation of $\ddot{x}$ to $\dot{x}$ and to $\dot{y}$ is given.

"The chief use of this analysis is to discover what curves are improper for domes, or what portions of given curves may be employed with safety. Domes are

are generally built for ornament; and we see that there is great room for indulging our fancy in the choice. All curves which are concave outwards will give domes of great firmness: they are also beautiful. The Gothic dome, whose outline is an undulated curve, may be made abundantly firm, especially if the upper part be convex and the lower concave outwards.

"The chief difficulty in the case of this analysis arises from the necessity of expressing the weight of the incumbent part, or $\int \dot{d} y \sqrt{\dot{x}^2+\dot{y}^2}$. This requires the measurement of the conoidal surface, which, in most cases, can be had only by approximation by means of infinite serieses.

"The surface of any circular portion of a sphere is very easily had, being equal to the circle described with a radius equal to the chord of half the arch. This radius is evidently $=\sqrt{\dot{x}^2+\dot{y}^2}$.

"In order to discover what portion of a hemisphere may be employed (for it is evident we cannot employ the whole) when the thickness of the vaulting is uniform, we may recur to the equation or formula $\frac{d\,y\,\dot{x}\sqrt{\dot{x}^2-\dot{y}^2}}{\ddot{x}}=\int d\,y\sqrt{\dot{x}^2+\dot{y}^2}$. Let a be the radius of the hemisphere. We have $\dot{x}=\frac{a\,y\,\dot{y}}{\sqrt{a^2-y^2}}$, and $\ddot{x}=\frac{a^2\dot{y}^2}{a^2-y^2|^{\frac{3}{2}}}$. Substituting these values in the formula, we obtain the equation $y^2\sqrt{a^2-y^2}=\int\frac{a^2 y\,\dot{y}}{\sqrt{a^2-y^2}}$. We easily obtain the fluent of the second member $=a^3-a^2\sqrt{a^2-y^2}$, and $y=a\sqrt{-\frac{1}{2}+\sqrt{\frac{5}{4}}}$. Therefore if the radius of the sphere be 1, the half breadth of the dome must not exceed $\sqrt{-\frac{1}{2}\times\sqrt{\frac{5}{4}}}$, or 0.786, and the height will be .618. The arch from the vertex is about 51° 49′. Much more of the hemisphere cannot stand, even though aided by the cement, and by the friction of the coursing joints. This last circumstance, by giving connection to the upper parts, causes the whole to press more vertically on the course below, and thus diminishes the outward thrust; but it at the same time diminishes the mutual abutment of the vertical joints, which is a great cause of firmness in the vaulting. A Gothic dome, of which the upper part is a portion of a sphere not exceeding 45° from the vertex, and the lower part is concave outwards, will be very strong, and not ungraceful.

"341. Persuaded that what has been said on the subject convinces the reader that a vaulting perfectly equilibrated throughout is by no means the best form, provided that the base is secured from separating, we think it unnecessary to give the investigation of that form, which has a considerable intricacy, and shall merely give its dimensions. The thickness is supposed uniform. The numbers in the first column of the table express the portion of the axis counted from the vertex, and those of the second column are the length of the ordinates.

AD	DB	AD	DB	AD	DB
0.4	100	610.4	1080	2990	1560
3.4	200	744	1140	3442	1600
11.4	300	904	1200	3972	1640
26.6	400	1100	1260	4432	1670
52.4	500	1336	1320	4952	1700
91.4	600	1522	1360	5336	1720
146.8	700	1738	1400	5756	1740
223.4	800	1984	1440	6214	1760
326.6	900	2270	1480	6714	1780
475.4	1000	2602	1520	7260	1800

"The curve formed according to these dimensions will not appear very graceful, because there is an abrupt change in its curvature at a small distance from its vertex; if, however, the middle be occupied by a lantern of equal or of smaller weight than the part whose place it supplies, the whole will be elegant, and free from this defect.

"The connexion of the parts arising from cement and from friction has a great effect on dome-vaulting. In the same way as in common arches and cylindrical vaulting, it enables an overload on one place to break the dome in a distant place. But the resistance to this effect is much greater in dome-vaulting, because it operates all round the overloaded part. Hence it happens that domes are much less shattered by partial violence, such as the falling of a bomb, or the like. Large holes may be broken in them without much affecting the rest; but, on the other hand, it greatly diminishes the strength which should be derived from the mutual pressure in the vertical joints. Friction prevents the sliding in of the arch-stones which produces this mutual pressure in the vertical joints, except in the very highest courses, and even there it greatly diminishes it. These causes make a great change in the form which gives the greatest strength; and as their laws of action are but very imperfectly understood as yet, it is perhaps impossible, in the present state of our knowledge, to determine this form with tolerable precision. We see plainly, however, that it allows a greater deviation from the best form than the other kind of vaulting; and domes may be made to rise perpendicular to the horizon at the base, although of no great thickness; a thing which must not be attempted in a plane arch. The immense addition of strength which may be derived from hooping largely compensates for all defects; and there is hardly any bounds to the extent to which a very thin dome-vaulting may be carried, when it is hooped or framed in the direction of the horizontal courses. The roof of the Halle du Bled at Paris is but a foot thick, and its diameter is more than 200, yet it appears to have abundant strength."

Scholium.

342. The section of the dome of St Paul's cathedral is part of an ellipse whose conjugate diameter is parallel to the horizon. It is built of wood, and confined by strong iron chains; and is supported by carpentry resting on a cone of brick work.

Chap.

Theory.

Chap. IX. *On the Force of Torsion.*

Fig. 2. 343. Definition. Let $g\,a$ be a metallic wire firmly fixed in the pincers g by means of the screw s; let the cylindrical weight P, furnished with an index $e\,o$, be suspended at the lower extremity of the wire; and let the axis of the cylinder, or the wire $g\,a$ produced, terminate in the centre of the divided circle MNO. Then, if the cylinder P is made to move round its axis so that the index $e\,o$ may describe the arch ON, the wire $g\,a$ will be twisted. If the cylinder be now left to itself, the wire will, in consequence of its elasticity, endeavour to recover its form; the index $e\,o$ will therefore move backwards from N, and oscillate round the axis of the cylinder. The force which produces these oscillations is called the *force of torsion*, and the angle measured by the arch ON is called the *angle of torsion*.

Prop. I.

344. To deduce formulæ for the oscillatory motion of the cylinder, on the supposition that the reaction of the force of torsion is proportional to the angle of torsion, or nearly proportional to it.

Fig. 3. Let PQ be a section of the cylinder P in fig. 2. and let all the elements of the cylinder be projected upon this circular section in d, d', d''. Let ACB, the primitive angle of torsion, be called A, and let this angle, after the time t, become AC b, so that it has been diminished by the angle BC b=M; then AC b=A—M= the angle of torsion after the time t.

Since the force of torsion is supposed to be proportional to the angle of torsion, the momentum of the force of torsion must be some multiple of that angle, or $n\times\overline{A-M}$, n being a constant coefficient, whose value depends on the nature, length, and thickness of the metallic wire. If, therefore, we call v the velocity of any point d at the end of the time t, when the angle of torsion becomes AC b, and r=C d the distance of the point d from the axis of rotation C, we shall have, by the principles of Dynamics,

$$n\times\overline{A-M}\times\dot{t}=\int d\,r\,\dot{v}.$$

But if CD, the radius of the cylinder, be equal a, and if u be the velocity of the point D after the time t, we have evidently $v:u=r:a$, and $v=\frac{r\,u}{a}$. Now by substituting the fluxion of this value of v in the place of $\dot{v}$ in the preceding formula, we have

$$n\times\overline{A-M}\times\dot{t}=\dot{u}\int\frac{d\,r^2}{a};$$

and since $\dot{t}=\frac{a\dot{M}}{u}$, we have by substitution

$$n\times\overline{A-M}\times\frac{a\dot{M}}{u}=\dot{u}\int\frac{d\,r^2}{a},$$

whose fluent is

$$n\times\overline{2AM-M^2}=u^2\int\frac{d\,r^2}{a^2}.$$

Taking the square root of both sides of the equation, we have

Theory.

$$\sqrt{n}\times\sqrt{\overline{2AM-M^2}}=u\times\left|\overline{\int\frac{d\,r^2}{a^2}}\right|^{\frac{1}{2}}.$$

Multiplying both sides by $\frac{a\dot{M}}{u}$, and dividing by $\sqrt{n}\times\sqrt{\overline{2AM-M^2}}$, the equation becomes

$$\frac{a\dot{M}}{u}=\frac{\frac{a\dot{M}}{u}\times u\times\left|\overline{\int\frac{d\,r^2}{a^2}}\right|^{\frac{1}{2}}}{\sqrt{n}\times\sqrt{\overline{2AM-M^2}}}=\frac{a\dot{M}\times\frac{1}{a}\times\left|\overline{\int d\,r^2}\right|^{\frac{1}{2}}}{\sqrt{n}\times\sqrt{\overline{2AM-M^2}}}$$

$$=\frac{\dot{M}\times\left|\overline{\int d\,r^2}\right|^{\frac{1}{2}}}{\sqrt{n}\times\sqrt{\overline{2AM-M^2}}}.$$

Therefore, since $\dot{t}=\frac{a\dot{M}}{u}$, we shall have

$$\dot{t}=\frac{\dot{M}\times\left|\overline{\int d\,r^2}\right|^{\frac{1}{2}}}{\sqrt{n}\times\sqrt{\overline{2AM-M^2}}},\text{ or}$$

$$\dot{t}=\frac{\dot{M}}{\sqrt{\overline{2AM-M^2}}}\times\left|\overline{\int\frac{d\,r^2}{n}}\right|^{\frac{1}{2}}.$$

But $\frac{\dot{M}}{\sqrt{\overline{2\,AM-M^2}}}$ represents an arch or angle whose radius is A and whose versed sine is M, which arch vanishes when M=0, and which becomes equal to 90° when M=A. Therefore the time of a complete oscillation will be

$$T=\left|\overline{\int\frac{p\,r^2}{n}}\right|^{\frac{1}{2}}\times 180^{\circ}.$$

345. In order to compare the force of torsion with the force of gravity in a pendulum, we have for the time of a complete oscillation of a pendulum whose length is l, g being the force of gravity,

$$T=\left|\overline{\frac{l}{g}}\right|^{\frac{1}{2}}180^{\circ}.$$

Therefore, since the time in which the cylinder oscillates must be equal to the time in which the pendulum oscillates, we have

$$\left|\overline{\int\frac{p\,r^2}{n}}\right|^{\frac{1}{2}}180^{\circ}=\left|\overline{\frac{l}{g}}\right|^{\frac{1}{2}}\times 180^{\circ}.$$

Hence dividing by 180°, and squaring both sides, we obtain

$$\left|\overline{\int\frac{p\,r^3}{n}}\right|=\frac{l}{g}.$$

We must therefore find for a cylinder the value of $\int p\,r^2$, or the sum of all the particles multiplied by the squares of their distances from the axis. Now, if we make π=6.28318 the ratio of the circumference of a circle to its radius, a= radius of the cylinder, λ= its length, d= its density; then we shall have for the area of its base $\frac{a^2\pi}{2}$, which multiplied by λ gives the solid content of the cylinder $=\frac{a^2\pi\lambda}{2}$, and this multiplied by

d

d gives $\frac{a^2 \pi \lambda d}{2}$ for the sum of all its particles. But as this is to be multiplied by the sum of the squares of all the distances of the particles from the centre C, we shall have $\int p r^2 = \frac{a^4 \pi^2 \lambda d}{4}$. But the number of particles in the cylinder, or the mass μ of the cylinder, is $\frac{a^2 \pi \lambda d}{2}$, therefore, substituting μ, instead of this value of it in the preceding equation, we have $\int p r^2 = \frac{\mu a^2}{2}$, and, dividing both sides by n, we have $\frac{\int p r^2}{n} = \frac{\mu a^2}{2n}$, and, extracting the square root and multiplying by 180, it becomes

$$\left|\frac{\int p r^2}{n}\right|^{\frac{1}{2}} \times 180° = \left|\frac{a^2}{2n}\right|^{\frac{1}{2}} \times 180°. \text{ Therefore}$$

$$T = \left|\frac{\mu a^2}{2n}\right|^{\frac{1}{2}} \times 180, \text{ and since } \int \frac{p r^2}{r} = \frac{l}{g},$$

$\frac{\mu a^2}{2n} = \frac{l}{g}$, and by reduction $n = \frac{g \mu a^2}{2l}$. But $g\,\mu$ is the weight W of the cylinder, therefore, by substituting W instead of $g\,\mu$, we obtain $n = \frac{P a^2}{2l}$, a very simple formula for determining the value of n from experiments.

If it were required to find a weight Q, which, acting at the extremity of a lever L, would have a momentum equal to the momentum of the force of torsion when the angle of torsion is A—M, we must make $Q \times L = n \times \overline{A-M}$.

346. In the preceding investigation we have supposed, what is conformable to experiment, that the force of torsion is proportional to the angle of torsion, which gives us $n \times \overline{A-M}$ for the momentum of that force. Let us now suppose that this momentum is altered by any quantity S, then the momentum of the force of torsion will become $n \times \overline{A-M} - S'$, and the general equation will assume this form

$$n \times \overline{A-M} - S \times \dot{t} = \dot{u} \int \frac{p r^2}{a};$$

and by multiplying in place of $\dot{t}$ its value $\frac{a \dot{M}}{u}$, and taking the fluent, we have

$$\overline{n \times 2\,AM - M^2} - 2 \int S\dot{M} = u^2 \int \frac{d r^2}{a^2}.$$

Now, in order to find the value of T or a complete oscillation, we must divide the oscillation into two parts, the first from B to A, where the force of torsion accelerates the velocity u, while the retarding force, arising from the resistance of the air and the imperfection of elasticity, diminishes the velocity u; and the second from A to B′, where the force of torsion, as well as the other forces, concur in diminishing u or retarding the motion.

347. *Ex.* 1. If $S = m \times \overline{A-M}^{\,\nu}$, we shall have for the state of motion in the first portion BA

$$n \times \overline{2\,AM - M^2} + \frac{2m \times \overline{A-M}|^{\nu+1}}{\nu+1} - \frac{2m A^{\nu+1}}{\nu+1} = u^2 \int \frac{p r^2}{a^2}$$

Hence, when the angle of torsion becomes equal to nothing, or $A - M = 0$, we have

$$n\,A^2 - \frac{2\,m\,A^{\nu+1}}{\nu+1} = UU \int \frac{p r^2}{a^2},$$

which dividing by $\int \frac{p r^2}{a^2}$, becomes

$$U^2 = \frac{n\,A^2 - \frac{2\,m\,A^{\nu+1}}{\nu+1}}{\int \frac{p\,r^2}{a^2}}.$$

Let us now consider the other part of the motion from A to B′, and suppose the angle AC $b' = M'$, we shall find, by calling U the velocity of the point A,

$$\frac{n\,M'^2}{2} + \frac{m\,M'^{\nu+1}}{\nu+1} = \frac{U^2 - u^2}{2} \times \int \frac{p\,r^2}{a^2}.$$

Then, by substituting instead of U its value as lately found, and taking the fluents, we shall have, when the velocity vanishes, or when the oscillation is finished,

$$A - M' = \frac{2m}{n \times \overline{\nu+2}} \times \frac{A^{\nu+1} + M'^{\nu+1}}{A + M'},$$

and if the retarding forces are such, that at each oscillation, the amplitude is a little diminished, we shall have for the approximate value of A—M′

$$A - M' = \frac{2\,m\,A\,\nu}{n \times \overline{\nu+1}},$$

and if the angle A—M′ is so small that it may be treated as a common fluxional quantity, we shall then have for any number of oscillations

$$N \times \frac{2\,m}{n \times \overline{\nu+1}} = \frac{1}{\nu-1} \times \frac{1}{M^{\nu-1}} - \frac{1}{A^{\nu-1}},$$

where M represents the angle to which A becomes equal after any number of oscillations N. Hence we obtain

$$M = \frac{1}{\left(N \times \frac{2\,m \times \overline{\nu+1}}{n \times \overline{\nu+1}} + \frac{1}{A^{\nu-1}}\right) \times^{\frac{1}{\nu-1}}},$$

which determines the value of M after any number of oscillations N.

348. *Ex.* 2. If $S = m \times \overline{A-M}|^{\nu} + m' \times \overline{A-M}|^{\nu'}$, m' and ν' being different values of m and ν, we shall obtain by following the mode of investigation in the last example,

$$n \times A - M = \frac{2\,m}{\nu+1} \times \frac{A^{\nu+1} + M^{\nu+1}}{A + M} + \frac{2\,m'}{\nu'+1} \times \frac{A^{\nu'+1} \times M^{\nu'+1}}{A + M}:$$

and if the retarding force is much less than the force of torsion, we shall have for an approximate value of $n \times \overline{A-M}$

$$n\times\overline{A-M}=\frac{2mA^{\nu}}{\nu+1}+\frac{2m'A^{\nu'}}{\nu'+1}.$$

349. *Ex.* 3. In general, if $S=m\times\overline{A-M}|^{\nu}+m'\times\overline{A-M}|^{\nu'}+m''\times\overline{A-M}|^{\nu''}+m'''\times\overline{A-M}|^{\nu'''}$, &c. we shall always have for an oscillation when S is smaller than the force of torsion.

$$n\times\overline{A-M}=\frac{2mA^{\nu}}{\nu+1}+\frac{2m'A^{\nu'}}{\nu'+1}+\frac{2m''A^{\nu''}}{\nu''+1}+\frac{2m'''A^{\nu'''}}{\nu'''+1},\ \&c.$$

350. Having thus given after Coulomb, the mode of deducing formulæ for the oscillatory motion of the cylinder, we shall proceed to give an account of the results of his experiments.

Torsion balance. Fig. 2.

In these experiments M. Coulomb employed the torsion balance represented in fig. 2. in which he suspended cylinders of different weights from iron and brass wires of different lengths and thicknesses; and by observing carefully the duration of a certain number of oscillations, he was enabled to determine, by means of the preceding formulæ, the laws of the force of torsion relative to the length, the thickness, and the nature of the wires employed. If the elasticity of the metallic wires had been perfect, and if the air opposed no resistance to the oscillating cylinder, it would continue to oscillate till its motion was stopped. The diminution of the amplitudes of the oscillations, therefore, being produced solely by the imperfection of elasticity, and by the resistance of the air, M. Coulomb was enabled, by observing the successive diminution of the amplitude of the oscillation, and by substracting the part of the change which was due to the resistance of the air, to ascertain, with the assistance of the preceding formulæ, according to what laws this elastic force of torsion was changed.

351. From a great number of experiments it appeared, that when the angle of torsion was not very great, the oscillations were sensibly isochronous; and therefore it may be regarded as a fundamental law, *That for all metallic wires, when the angles of torsion are not very great, the force of torsion is sensibly proportional to the angle of torsion.* Hence, as the preceding formulæ are founded on this supposition, they may be safely applied to the experiments.

352. In all the experiments, a cylinder of two pounds weight oscillated in twice the time employed by a cylinder which weighed only half a pound; and therefore *the duration of the oscillations is as the square root of the weights of the oscillating cylinders.* Consequently the tension of the wires has no sensible influence upon the force of torsion. If the tensions however be very great relative to the strength of the metal, the force of torsion does suffer a change; for when the weight of the cylinder, and consequently the tension of the wire, is increased, the wire is lengthened, and as this diminishes the diameter of the wire, the duration of the oscillation must evidently be affected.

353. When the lengths of the wires are varied without changing their diameters or the weights of the cylinders, *the times of the same number of oscillations are as the square roots of the lengths of the wires*, a result also deducible from theory.

354. When the diameters of the wires are varied without changing their lengths, or the weight of the cylinders, the momentum of the force of torsion varied as the fourth power of the diameters of the wires. Now this result is perfectly conformable to theory; for if we suppose two wires of the same substance, and of the same length, but having their diameters as one to two, it is obvious that in the wire whose diameter is double of the other, there are four times as many parts extended by torsion, as in the smaller wire, and that the mean extension of all these parts will be proportional to the diameter of a wire, the same as the mean arm of a lever is, relative to the axis of rotation. Hence it appears that, according to theory, the force of torsion of two wires of the same nature and of the same length, but of different diameters, is proportional to the fourth power of their diameter.

355. From this it follows in general, that in metallic wires the momentum of torsion is directly in the compound ratio of the angle of torsion and the fourth power of their diameter, and inversely as the length of the wires. If a therefore be the angle of torsion, λ the length of the thread, δ its diameter, and F the force of torsion, we shall have

$$F=\frac{ma\delta^4}{l},$$

where m is a constant coefficient for wires of the same metal, depending on the tenacity of the metal, and deducible from experiment.

356. When the angle of torsion is not great, relative to the length of the wire, the index of the cylinder returns to the position which it had before the torsion took place, or, in other words, the wire untwists itself by the same quantity by which it had been twisted. But when the angle of torsion is very great, the wire does not completely untwist itself, and therefore the centre of torsion will have advanced by a quantity equal to that which it has not untwisted.—When the angle of torsion was below 45°, the decrements of the amplitudes of the oscillations were nearly proportional to the amplitudes of the angle of torsion; but when the angle exceeded 45°, the decrements increased in a much greater ratio.—The centre of torsion did not begin to advance or be displaced till the angle of torsion was nearly a semicircle: it displacement was very irregular till the angle was one circle and 10 degrees, but beyond this angle the torsion remained nearly the same for all angles.

357. The theory of torsion is particularly useful in delicate researches, where small forces are to be ascertained with a precision which cannot be obtained by ordinary means. It has been successfully employed by Coulomb in discovering the laws of the forces of electricity and magnetism, and in determining the resistance of fluids when the velocities are very small.

PART II. ON THE CONSTRUCTION OF MACHINERY.

358. WE have already seen, when considering the maximum effects of machines, the various causes which affect their performance. It appeared from that investigation, that there must be a certain relation between the velocities of the impelled and working points of a machine, or between the power and the resistance to be overcome, before it can produce a maximum effect, and therefore it must be the first object of the engineer to ascertain that velocity, and to employ it in the construction of this machine. The performance of the machine is also influenced by the friction and inertia of its various parts; and as both these act as resistances, and therefore destroy a considerable portion of the impelling power, it becomes an object of great importance to attend to the simplification of the machinery, and to ascertain the nature of friction so as to diminish its effect, either by the application of unguents or by mechanical contrivances. Since the impelled and working points of a machine are generally connected by means of toothed wheels, the teeth must be formed in such a manner, that the wheels may always act upon each other with the same force, otherwise the velocity of the machine will be variable, and its structure soon injured by the irregularity of its motion. The irregular motion of machines sometimes arises from the nature of the machinery, from an inequality in the resistance to be overcome, and from the nature of the impelling power. In large machines, the momenta of their parts are generally sufficient to equalize these irregularities; but in machines of a small size, and in those where the irregularities are considerable, we must employ fly-wheels for regulating and rendering uniform their variable movements. These various subjects, and others intimately connected with them, we shall now proceed to discuss in their order.

Chap. I. *On the Proportion between the Velocity of the Impelled and Working points of Machines, and between the Power and Resistance, in order that they may perform the greatest work.*

359. In the chapter on the maximum effect of machines we have deduced formulæ containing x and y, the velocities of the impelled and working points of the machines, and including every circumstance which can affect their motion. The formula which exhibits the value of y, or the velocity of the working point, assumes various forms, according as we neglect one or more of the elements of which it is composed.—When the work to be performed resists only by its inertia, which is the case in urging round a millstone or heavy fly, the quantity R may be neglected, and the second formula, (Page 92. col. 2.) should be employed. In small machines, and particularly in those where the motion is conveyed by wheels with epicycloidal teeth, the friction is very trifling, and the element φ may be safely omitted. In corn and saw mills, the quantity b or the inertia of the resistance may be left out of the formula, as the motion communicated to the flour or to the saw dust is too small to be subjected to computation. In machines where one heavy body is employed to raise another merely by its weight, the inertia of the power and the resistance, viz. a, b, are proportional to P, R, the powers and resistances themselves, and consequently P, R may be substituted in the formula, in the place of a, b.—The engineer therefore must consider, before he construct his machine, what elements should enter into the formula, and what should be omitted, in order that he may adapt it to the circumstances of the case, and obtain from his machine the greatest possible effect.

360. When the inertia of the power and that of the resistance are proportional to the power and resistance themselves; and when the inertia and friction of the machine may be omitted, the formula becomes $y=\sqrt{\frac{P}{R}+1}-1$ from which the following table is computed, which contains the values of y for different values of P; R being supposed $=10$, and $m=1$. To find the relation between the velocities of the impelled and working points of a machine.

Table containing the best Proportions between the Velocities of the Impelled and Working Points of a Machine, or between the Levers by which the Power and Resistance act.

Proportional value of the impelling power, or P.	Value of the velocities of the working point or y; or of the lever by which the resistance acts, that of x being one.	Proportional value of the impelling power, or P.	Value of the velocities of the working point or y; or of the lever by which the resistance acts, that of x being 1.
1	0.048809	20	0.732051
2	0.095445	21	0.760682
3	0.140175	22	0.788854
4	0.183216	23	0.816590
5	0.224745	24	0.843900
6	0.264911	25	0.870800
7	0.303841	26	0.897300
8	0.341641	27	0.923500
9	0.378405	28	0.949400
10	0.414214	29	0.974800
11	0.449138	30	1.000000
12	0.483240	40	1.236200
13	0.516575	50	1.449500
14	0.549193	60	1.645700
15	0.581139	70	1.828400
16	0.612451	80	2.000000
17	0.643168	90	2.162300
18	0.673320	100	2.316600
19	0.702938		

In order to explain the use of this table, let us suppose that it is required to raise one cubic foot of water in a second, by means of a stream which discharges three cubic feet of water in a second; and let it be required to find the construetion of a wheel and axle for performing this work; that is, the diameter of the axle, that of the wheel being 6. Here the power is evidently 3 cubic feet, while the resistance is only one cubic foot, therefore $P=3$ R; but in the preceding table

$R=10$, consequently $P=3\times10=30$. But it appears from the table that when $P=30$, y or the diameter of the axle is 1, upon the supposition that the diameter x of the wheel is 1; but as x must be $=6$, we shall have $y=6$.

361. Instead of using the preceding table, we might find the best proportion between x and y by a kind of tentative process, from the formula $\frac{PxRy-R^2y^2}{Px^2+Ry^2}$, which expresses the work performed. This method is indeed tedious; and we mention it only for the sake of showing the conformity of the results, and of proving that there is a certain proportion between x and y which gives a maximum effect. Let $x=6$, as in the preceding paragraph, and let us suppose y to be successively 5, 6, and 7, in order to see which of these values is the best. Since $P=3$, and $R=1$, and $x=6$, we have

$$\text{When } y=5 \quad \frac{PxRy-R^2y^2}{Px^2+Ry^2}=\frac{3\times6\times1\times5-1\times5\times5}{3\times6\times6+1\times5\times5}=\frac{65}{133}=0.488$$

$$\text{When } y=6 \quad \frac{PxRy-R^2y^2}{Px^2+Ry^2}=\frac{3\times6\times1\times6-1\times6\times6}{3\times6\times6+1\times6\times6}=\frac{72}{144}=0.500$$

$$\text{When } y=7 \quad \frac{PxRy-R^2y^2}{Px^2+Ry^2}=\frac{3\times6\times1\times7-1\times7\times7}{3\times6\times6+1\times7\times7}=\frac{77}{157}=0.49045$$

It appears therefore that when $y=5, 6, 7$, the work performed is 0.488; 0.5000; 0.49045; so that the effect is a maximum when $y=6$, a result similar to what was obtained from the table.

To find the best proportion between the power and the resistance.

362. When the machine is already constructed, x and y cannot be varied so as to obtain a maximum effect. The same object however will be gained by properly adjusting the power to the work when the work cannot be altered, or the work to the power when the power is determinate. The formulæ in Prop. 2. Chap. 7. exhibit the values of R under many circumstances, and it depends on the judgment of the engineer to select such of them as are adapted to all the conditions of the case.

363. The following table is founded on the formula $R=\sqrt{\frac{y+1}{y^2}}-\frac{1}{y}$, which answers to the case where the inertia of the impelling power is the same with its pressure, and where the inertia and the friction of the machine may be safely neglected. The second column contains the different values of R corresponding to the values of y in the first column. The numbers in the third column shew the ratio of y to R, or they have the same proportion to 1, which R has to the resistance which will balance P. In the table it is supposed that $P=1$ and $x=1$.

Table containing the best proportions between the Power *and the* Resistance, *the inertia of the impelling power being the same with its pressure, and the friction and inertia of the Machine being omitted.*

Values of y, or the velocity of the working point; x being equal to 1.	Values of R, or the resistance to be overcome, P being $=1$.	Ratio of R to the resistance which would balance P.	Values of y, or the velocity of the working point; x being equal to 1.	Values of R, or the resistance to be overcome, P being $=1$.	Ratio of R to the resistance which would balance P.
$\frac{1}{4}$	1.8885	0.4724 to 1	7	0.03731	0.26117 to 1
$\frac{1}{3}$	1.3928	0.4639 ——	8	0.03125	0.25000 ——
$\frac{1}{2}$	0.8986	0.4493 ——	9	0.02669	0.24021 ——
1	0.4142	0.4142 ——	10	0.02317	0.23170 ——
2	0.1830	0.3660 ——	11	0.02037	0.22407 ——
3	0.1111	0.3333 ——	12	0.01809	0.21708 ——
4	0.0772	0.3088 ——	13	0.01622	0.21086 ——
5	0.0580	0.2900 ——	14	0.01466	0.20524 ——
6	0.0457	0.2742 ——	15	0.01333	0.19995 ——

364. To exemplify the use of the preceding table, let us suppose that we are to raise water by means of a simple pulley and bucket, with a power $=10$, and that it is required to find the resistance R, or the quantity of water which must be put into the bucket, in order that the work performed may be a maximum. In the simple pulley, x, y, the arms of the vertical levers or the velocities of the impelled and working points are equal; and since x is supposed in the table to be $=1$, we have $y=1$, which corresponds in the table with 0.4142, the value of R, P being $=1$ in the table: But in the present case $P=10$. Therefore, $10:1=0.4142:4.142$, the value of R when $P=10$.

365. The same result might be obtained in a more circuitous method by means of the formula $\frac{PxRy-R^2y^2}{Px^2+Ry^2}$, which expresses the performance of the machine. Thus, let $x=1$; $y=1$; $P=10$, and let us suppose R successively equal to 3; 4; 4.142; 5; so that we may determine which of these values gives the greatest performance.

When

When R=3, the preceding formula becomes $\frac{\overline{10\times 3}-\overline{3\times 3}}{10+3}=\frac{21}{13}=1.6154$.

When R=4, the formula becomes $\frac{10\times 4-4\times 4}{10+4}=\frac{24}{14}=1.7143$.

When R=4.142, the formula becomes $\frac{10\times 4.142-\overline{4.142}^2}{10+4.142}=\frac{24.26384}{14.142}=1.7157$.

When R=5, the formula becomes $\frac{10\times 5-5\times 5}{10+5}=\frac{25}{15}=1.6666$.

Hence it appears, that when R=3; 4; 4.142; 5; the work performed is respectively = 1.6154; 1.7143; 1.7157; 1.6666; so that the work performed is a maximum when R is =4.142, the same result which was obtained from the table.

Chap. II. *On the Simplification of Machinery.*

366. As the inertia of every machine adds greatly to the resistance to be overcome, and as the friction of the communicating parts is proportional to the pressure, it becomes a matter of great practical importance, that the different parts of a machine should be proportioned to the strains to which they are exposed. If the beam of a steam-engine, for example, is larger than what is necessary, an immense portion of the impelling power must be destroyed at every stroke of the piston, by dragging the superfluous mass from a state of rest into motion; the pressure upon the gudgeons will also be increased, and their friction in their sockets proportionally enlarged. The engineer, therefore, should be well acquainted with the strength of the materials of which the machine is to be constructed, and should frame its different parts in such a manner that they may not be heavier than what is necessary for resisting the forces with which they are urged.—When the motions of the machine are necessarily irregular, and when the machine may be exposed to accidental strains, the parts must be made considerably stronger than what is necessary for resisting its ordinary strains; but it is not often that such a precaution should be observed. The gudgeons of water-wheels, and of the beams of steam-engines, ought to be made as short and small as possible, as the friction increases with the rubbing surfaces. This is very seldom attended to in the construction of water-wheels. The diameter of the gudgeons is frequently thrice as large as what is necessary for supporting the weight of the wheel.

367. In the construction of machinery we must not only attend to the simplification of the parts, but also to the number of these parts, and the mode of connecting them. From the nature and quantity of the work to be performed, it is easy to ascertain the velocity of the working point which is most proper for performing it. Now this velocity may be procured in a variety of ways, either by a perplexing multiplicity of wheels, or by more simple combinations. The choice of these combinations must be left solely to the judgement of the engineer, as no general rules can be laid down to direct him. It may be useful, however, to remark, that the power should always be applied as near as possible to the working point of the machine, and that when one wheel drives another, the diameter of the one should never be great, when the diameter of the other is very small. The size of wheels is often determined from the strains to which they are exposed. If, for example, we are obliged to give a certain velocity to an axle by means of a wheel with 120 teeth, and if the force with which this wheel is urged, requires the teeth to be at least one inch thick in order to prevent them from breaking, we shall be obliged to make its diameter at least seven feet; for supposing the spaces between the teeth to be equal to the thickness of the teeth, the circumference of the wheel must at least be equal to 120+120=240 inches, the sum of the teeth and their intervals, which gives a diameter of six feet eight inches. There are some cases where our choice of combination must be directed by the nature of the machinery. If the work to be performed is a load raised with a certain velocity by means of a rope winding round a hollow drum, and if the simplest combination of mechanical powers for producing this velocity should give a small diameter to the drum, then this combination must give way to another which corresponds with a larger size of the drum, for, on account of the inflexibility of the ropes, a great portion of the impelling power would be wasted in winding them about the circumference of a small drum.

Description of a powerful capstane. Plate CCCXXIII. fig. 4.

368. The advantages of simplifying machinery are well exemplified in the following capstane, which unites great strength and simplicity. It is represented in fig. 4. where AD is a compound barrel composed of two cylinders of different radii. The rope DEC is fixed at the extremity of the cylinder D: and after passing over the pulley E, which is attached to the load by means of the hook F, it is coiled round the other cylinder D, and fixed at its upper end. The capstane bar AB urges the compound barrel CD about its axis, so that while the rope coils round the cylinder D it unwinds itself from the cylinder C. Let us suppose that the diameter of the part D of the barrel is 21 inches, while the diameter of the part C is only 20 inches, and let the pulley E be 20 inches in diameter. When the barrel AD, therefore, has performed one complete revolution by the pressure exerted at B, 63 inches of rope, equal to the circumference of the cylinder, will be gathered upon the cylinder D, and 60 inches will be unwinded from the cylinder C. The quantity of wound rope, therefore, exceeds the quantity that is unwound by 63—60=3 inches, the difference of their respective perimeters; and the half of this quantity, or $1\frac{1}{2}$ inches, will be the space through which the load or pulley E moves by one turn of the bar. If a simple capstane of the same dimensions had been employed, the length of rope coiled round the barrel would have been 60 inches;

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inches; and the space described by the pulley, or load to be overcome, would have been 30 inches. Now, as the power is to the weight as the velocity of the weight is to the velocity of the power, and as the velocity of the power is the same in both capstanes, the weights which they will raise will be as $1\frac{1}{2}$ to 30. If it is wished to double the power of the machine, we have only to cover the cylinder C with lathes a quarter of an inch thick, so that the difference between the radii of each cylinder may be half as little as before; for it is obvious that the power of the capstane increases as the difference between the radii of the cylinders is diminished. As we increase the power, therefore, we increase the strength of our machine, while all other engines are proportionably enfeebled by an augmentation of power. Were we for example to increase the power of the common capstane, we must diminish the barrel in the same proportion, supposing the bar AB not to admit of being lengthened, which will not only diminish its strength, but destroy much of its power by the additional flexure of the rope.—This capstane may be easily converted into a crane, by giving the compound barrel a horizontal position, and substituting a winch instead of the bar AB. The superiority of such a crane above the common ones does not require to be pointed out; but it has this additional advantage, that it allows the weight to stop at any part of its progress, without the aid of a ratchet wheel and catch, because the two parts of the rope pull on the contrary sides of the barrel. The rope indeed which coils round the larger part of the barrel acts with a larger lever, and consequently with greater force than the other; but as this excess of force is not sufficient to overcome the friction of the machine, the weight will remain stationary in any part of its path. (*Appendix to Ferguson's Lectures*, vol. ii.).

Compound double machine on the same principle.

Fig. 5.

369. The principle on which the preceding capstane is constructed, might be applied with great advantage when two separate axles AC, BD are driven by means of the winch H and the wheels B and A. It is evident that when the winch is turned round in one direction, the rope R is unwinded from the axle BD; the wheel B drives the wheel A, so that the axle AC moves in a direction opposite to that of BD, and the rope is coiled round the axle AC. If the wheels A, B are of the same diameter and the same number of teeth, the weight W will be stationary, as the rope winded about one axle will be always equal to what is unwinded from the other. If the wheels have different diameters, or different numbers of teeth, the quantity of rope wound round the one axle will exceed what is unwound from the other, and the weight will be raised.

Chap. III. *On the Nature of Friction and the Method of diminishing its effects in Machinery; and on the Rigidity of Ropes.*

370. The friction generated in the communicating parts of machinery, opposes such a resistance to the impelling power, and is so injurious to the machine itself, that an acquaintance with the nature and effects of this retarding force, and with the method of diminishing its effects on machinery, is of infinite importance to the practical mechanic.

371. The subject of friction has been examined at great length by Amontons, Bulfinger, Parent, Euler, and Bossut, and has lately occupied the attention of our ingenious countryman Mr Vince of Cambridge.

Result of Vince's experiments.

He found that the friction of hard bodies in motion is an uniformly retarding force, and that the quantity of friction considered as equivalent to a weight drawing the body backwards is equal to $M\frac{\overline{M+W}\times S}{g\,t^2}$, where M is the moving force expressed by its weight, W the weight of the body upon the horizontal plane, S the space through which the moving force or weight descended in the time t, and $g=16.087$ feet, the force of gravity. Mr Vince also found that the quantity of friction increases in a less ratio than the quantity of matter or weight of the body, and that the friction of a body does not continue the same when it has different surfaces applied to the plane on which it moves, but that the smallest surfaces will have the least friction.

Experiments of Coulomb.

372. Notwithstanding the attempts of preceding philosophers to unfold the nature of friction, it was reserved for the celebrated Coulomb to surmount the difficulties which are inseparable from such an investigation, and to give an accurate and satisfactory view of this difficult branch of mechanical philosophy. By employing large bodies and conducting his experiments on a large scale, he has corrected several errors which arose from the limited experiments of others; he has brought to light many new and striking phenomena, and confirmed others which were hitherto but partially established. As it would be foreign to the nature of this work to follow this ingenious philosopher through his numerous and varied experiments, we shall only present the reader with the interesting results to which they led.

1. The friction of homogeneous bodies, or bodies of the same kind, moving upon one another, is generally supposed to be greater than that of heterogeneous bodies; but Coulomb has shewn that there are exceptions to this rule. He found, for example, that the friction of oak upon oak was equal to $\frac{1}{2.34}$ of the force of pression; the friction of pine against pine $\frac{1}{1.78}$, and that of oak against pine $\frac{1}{1.5}$. The friction of oak against copper was $\frac{1}{5.5}$, and that of oak against iron nearly the same.

2. It was generally supposed, that in the case of wood, the friction is greatest when the bodies are dragged contrary to the course of their fibres; but Coulomb has shewn that the friction is in this case sometimes the smallest. When the bodies moved in the direction of their fibres, the friction was $\frac{1}{2.34}$ of the force with which they were pressed together; but when the motion was contrary to the courses of the fibres, the friction was only $\frac{1}{3.76}$.

3. *The longer the rubbing surfaces remain in contact, the greater is their friction.*—When wood was moved upon

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upon wood, according to the direction of the fibres, the friction was increased by keeping the surfaces in contact for a few seconds; and when the time was prolonged to a minute, the friction seemed to have reached its farthest limit. But when the motion was contrary to the course of the fibres, a greater time was necessary before the friction arrived at its maximum. When wood was moved upon metal, the friction did not attain its maximum till the surfaces continued in contact for five or six days; and it is very remarkable, that when wooden surfaces were anointed with tallow, the time requisite for producing the greatest quantity of frictiou is increased. The increase of friction which is generated by prolonging the time of contact is so great, that a body weighing 1650 pounds was moved with a force of 64 pounds when first laid upon its corresponding surface. After having remained in contact for the space of three seconds, it required 160 pounds to put it in motion; and, when the time was prolonged to fix days, it could scarcely be moved with a force of 622 pounds. When the surfaces of metallic bodies were moved upon one another, the time of producing a maximum of friction was not changed by the interposition of olive oil; it was increased, however, by employing swine's grease as an unguent, and was prolonged to five or six days by besmearing the surfaces with tallow.

4. *Friction is in general proportional to the force with which the rubbing surfaces are pressed together; and is, for the most part, equal to between* $\frac{1}{2}$ *and* $\frac{1}{4}$ *of that force.*—In order to prove the first part of this proposition. Coulomb employed a large piece of wood, whose surface contained three square feet, and loaded it successively with 74 pounds, 874 pounds, and 2474 pounds. In these cases the friction was successively $\frac{1}{2.46}$, $\frac{1}{2.16}$, $\frac{1}{2.21}$ of the force of pression; and when a less surface and other weights were used, the friction was $\frac{1}{2.36}$, $\frac{1}{2.42}$, $\frac{1}{2.40}$. Similar results were obtained in all Coulomb's experiments, even when metallic surfaces were employed. The second part of the proposition has also been established by Coulomb. He found that the greatest friction is engendered when oak moves upon pine, and that it amounts to $\frac{1}{1.78}$ of the force of pression; on the contrary, when iron moves upon brass, the least friction is produced, and it amounts to $\frac{1}{4}$ of the force of pression.

5. *Friction is in general not increased by augmenting the rubbing surfaces.*—When a superficies of three feet square was employed, the friction, with different weights, was $\frac{1}{2.28}$ at a medium; but when a small surface was used, the friction instead of being greater, as might have been expected, was only $\frac{1}{2.39}$.

[Fr]iction di[min]ished [by] increas[e of] the ve[loc]ity.

6. *Friction for the most part is not augmented by an increase of velocity.* In some cases, *it is diminished by an augmentation of celerity.*—M. Coulomb found, that when wood moved upon wood in the direction of the fibres, the friction was a constant quantity, however much the velocity was varied; but that when the surfaces were very small in respect to the force with which they were pressed, *the friction was diminished by augmenting the rapidity:* the friction, on the contrary, was increased when the surfaces were very large when compared with the force of pression. When the wood was moved contrary to the direction of its fibres, the friction in every case remained the same. If wood be moved upon metals, the friction is greatly increased by an increase of velocity; and when metals move upon wood besmeared with tallow, the friction is still augmented by adding to the velocity. When metals move upon metals, the friction is always a constant quantity; but when heterogeneous substances are employed which are not bedaubed with tallow, the friction is so increased with the velocity, as to form an arithmetical progression when the velocities form a geometrical one.

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7. *The friction of loaded cylinders rolling upon a horizontal plane, is in the direct ratio of their weights, and the inverse ratio of their diameters.* In Coulomb's experiments, the friction of cylinders of guaiacum wood, which were two inches in diameter, and were loaded with 1000 pounds, was 18 pounds or $\frac{1}{56}$ of the force of pression. In cylinders of elm, the friction was greater by $\frac{2}{5}$, and was scarcely diminished by the interposition of tallow.

373. From a variety of experiments on the friction of the axes of pulleys, Coulomb obtained the following results.—When an iron axle moved in a brass bush the friction was $\frac{1}{6}$ of the pression; but when the bush was besmeared with very clean tallow, the friction was only $\frac{1}{11}$; when swine's grease was interposed, the friction amounted to $\frac{1}{8.5}$; and when olive oil was employed as an unguent, the friction was never less than $\frac{1}{8}$ or $\frac{1}{7.5}$, When the axis was of green oak, and the bush of guaiacum wood, the friction was $\frac{1}{26}$ when tallow was interposed; but when the tallow was removed, so that a small quantity only covered the surface, the friction was increased to $\frac{1}{17}$. When the bush was made of elm, the friction was in similar circumstances $\frac{1}{33}$ and $\frac{1}{20}$, which is the least of all. If the axis be made of box, and the bush of guaiacum wood, the friction will be $\frac{1}{23}$ and $\frac{1}{14}$, circumstances being the same as before. If the axle be of boxwood, and the bush of elm, the friction will be $\frac{1}{29}$ and $\frac{1}{20}$; and if the axle be of iron and the bush of elm, the friction will be $\frac{1}{20}$ of the force of pression.

Method of diminishing the effects of friction.

374. Having thus considered the nature and effects of friction, we shall now attend to the method of lessening the resistance which it opposes to the motion of machines. The most efficacious mode of accomplishing this is to convert that species of friction which arises from one body being dragged over another, into that which is occasioned by one body rolling upon another. As this will always diminish the resistance, it may be easily effected by applying wheels or rollers to the sockets or bushes which sustain the gudgeons of large wheels, and the axles of wheel carriages. Casatus seems to have been the first who recommended this apparatus. It was afterwards mentioned by Sturmius and Wolfius; but was not used in practice till Sully applied it to clocks in the year 1716, and Mondran to cranes in 1725. Notwithstanding these solitary attempts to introduce friction wheels, they seem to have attracted little notice till the celebrated Euler examined

Friction wheels.

and

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and explained, with his usual accuracy, their nature and advantages. The diameter of the gudgeons and pivots should be made as small as the weight of the wheel and the impelling force will permit. The gudgeons should rest upon wheels as large as circumstances will allow, having their axes as near each other as possible, but no thicker than what is absolutely necessary to sustain the superincumbent weight. When these precautions are properly attended to, the resistance which arises from the friction of the gudgeon, &c. will be extremely trifling.

Friction may be diminished by a judicious application of the impelling power.

375. The effects of friction may likewise in some measure be removed by a judicious application of the impelling power, and by proportioning the size of the friction wheels to the pressure which they severally sustain. If we suppose, for example, that the weight of a wheel, whose iron gudgeons move in bushes of brass, is 100 pounds; then the friction arising from both its gudgeons will be equivalent to 25 pounds. If we suppose, also, that a force equal to 40 pounds is employed to impel the wheel, and acts in the direction of gravity, as in the cases of overshot wheels, the pressure of the gudgeons upon their supports will then be 140 pounds and the friction 35 pounds. But if the force of 40 pounds could be applied in such a manner as to act in direct opposition to the wheel's weight, the pressure of the gudgeons upon their supports would be 100—40, or 60 pounds, and the friction only 15 pounds. It is impossible, indeed, to make the moving force act in direct opposition to the gravity of the wheel, in the case of water mills; and it is often impracticable for the engineer to apply the impelling power but in a given way: but there are many cases in which the moving force may be so exerted, as at least not to increase the friction which arises from the wheel's weight.

376. When the moving force is not exerted in a perpendicular direction, but obliquely as in undershot wheels, the gudgeon will press with greater force on one part of the socket than on any other part. This point will evidently be on the side of the bush opposite to that where the power is applied; and its distance from the lowest point of the socket, which is supposed circular and concentric with the gudgeon, being called x, we shall have Tang. $x = \frac{H}{V}$, that is, the tangent of the arch contained between the point of greatest pressure and the lowest part of the bush, is equal to the sum of all the horizontal forces, divided by the sum of all the vertical forces and the weight of the wheel, H representing the former, and V the latter quantities. The point of greatest pressure being thus determined, the gudgeon must be supported at that part by the largest friction wheel, in order to equalize the friction upon their axles.

The application of these general principles to particular cases is so simple as not to require any illustration. To aid the conceptions, however, of the practical mechanic, we may mention two cases in which friction wheels have been successfully employed.

Plate CCCXXIII. fig. 6.

377. Mr Gottlieb, the constructor of a new crane, has received a patent for what he calls an anti-attrition axle-tree, the beneficial effects of which he has ascertained by a variety of trials. It consists of a steel roller R about four or six inches long, which turns within a groove cut in the inferior part of the axle-tree C which runs in the nave AB of the wheel. When the wheel-carriages are at rest, Mr Gottlieb has given the friction wheel its proper position; but it is evident that the point of greatest pressure will change when they are put in motion, and will be nearer the front of the carriage. This point, however, will vary with the weight of the load; but it is sufficiently obvious that the friction roller should be at a little distance from the lowest point of the axle-tree.

378. Mr Gamett of Bristol has applied friction rollers in a different manner, which does not, like the preceding method, weaken the axle-tree. Instead of fixing them in the iron part of the axle, he leaves a space between the nave and the axis to be filled with equal rollers almost touching each other. A section of this apparatus is represented in fig. 7. where ABCD is the metallic ring inserted in the nave of the wheel. The axle-tree is represented at E, placed between the friction rollers I, I, I, made of metal, and having their axes inserted into a circle of brass which passes through their centres. The circles are rivetted together by means of bolts passing between the rollers, in order to keep them separate and parallel.

Fig. 7.

379. As it appears from the experiments of Coulomb, that the least friction is generated when polished iron moves upon brass, the gudgeons and pivots of wheels, and the axles of friction rollers, should all be made of polished iron; and the bushes in which these gudgeons move, and the friction wheels, should be formed of polished brass.

Friction diminished by unguents.

380. When every mechanical contrivance has been adopted for diminishing the obstruction which arises from the attrition of the communicating parts, it may be still farther removed by the judicious application of unguents. The most proper for this purpose are swine's grease and tallow when the surfaces are made of wood, and oil when they are of metal. When the force with which the surfaces are pressed together is very great, tallow will diminish the friction more than swine's grease. When the wooden surfaces are very small, unguents will lessen their friction a little, but it will be greatly diminished if wood moves upon metal greased with tallow. If the velocities, however, are increased, or the unguent not often enough renewed, in both these cases, but particularly in the last, the unguent will be more injurious than useful. The best mode of applying it, is to cover the rubbing surfaces with as thin a stratum as possible, for the friction will then be a constant quantity, and will not be increased by an augmentation of velocity.

381. In small works of wood, the interposition of the powder of black lead has been found very useful in relieving the motion. The ropes of pulleys should be rubbed with tallow, and whenever the screw is used, the square threads should be preferred." *Appendix to Ferguson's Lectures*, vol. ii.

On the rigidity of ropes.

382. When ropes pass over cylinders or pulleys, a considerable force is necessary to bend them into the form of the circumference round which they are coiled. The force which is necessary to overcome this resistance is called the *stiffness* or *rigidity* of the ropes. This important subject was first examined by Amontons, * who contrived an ingenious apparatus for ascertaining the rigidity of ropes. His experiments were repeated and confirmed in part by subsequent philosophers, but particularly by M. Coulomb, who has investigated the subject

* *Mem. Acad.* 1699, p. 217.

ject with more care and success than any of his predecessors. His experiments were made both with the apparatus of Amontons, and with one of his own invention; and as there was no great discrepancy in the results, he was authorised to place more confidence in his experiments. The limits of this article will not permit us to give an account of the manner in which the experiments were conducted, or even to give a detailed view of the various conclusions which were obtained. We can only present the reader with some of those leading results which may be useful in the construction of machinery.

1. The rigidity of ropes increases, the more that the fibres of which they are composed are twisted.

2. The rigidity of ropes increases in the duplicate ratio of their diameters. According to Amontons and Desaguliers, the rigidity increases in the simple ratio of the diameters of the ropes; but this probably arose from the flexibility of the ropes which they employed: for Desaguliers remarks, that when he used a rope whose diameter was half an inch, its rigidity was increased in a greater proportion; so that it is probable that if they had employed ropes from two to four inches in diameter, like those used by Coulomb, they would have obtained similar results. (See N° 9.)

3. The rigidity of ropes is in the simple and direct ratio of their tension.

4. The rigidity of ropes is in the inverse ratio of the diameters of the cylinders round which they are coiled.

5. In general, the rigidity of ropes is directly as their tensions and the squares of their diameters, and inversely as the diameters of the cylinders round which they are wound.

6. The rigidity of ropes increases so little with the velocity of the machine, that it need not be taken into the account when computing the effects of machines.

7. The rigidity of small ropes is diminished when penetrated with moisture; but when the ropes are thick, their rigidity is increased.

8. The rigidity of ropes is increased and their strength diminished when they are covered with pitch; but when ropes of this kind are alternately immersed in the sea and exposed to the air, they last longer than when they are not pitched.—This increase of rigidity, however, is not so perceptible in small ropes as in those which are pretty thick.

9. The rigidity of ropes covered with pitch is a sixth part greater during frost than in the middle of summer, but this increase of rigidity does not follow the ratio of their tensions.

10. The resistance to be overcome in bending a rope over a pulley or cylinder may be represented by a formula composed of two terms. The first term $\frac{aD^n}{r}$ is a constant quantity independent of tension, a being a constant quantity determined by experiment, D^n a power of the diameter D of the rope, and r the radius of the pulley or cylinder round which the rope is coiled. The second term of the formula is $T \times \frac{bD^n}{r}$, where T is the tension of the rope, b a constant quantity, and D^n and r the same as before. Hence the complete formula is $\frac{a\,D^n}{r} + T \times \frac{b\,D^n}{r} = \frac{D^n}{r} \times a + T\,b$. The exponent n of the quantity D diminishes with the flexibility of the rope, but is generally equal to 1.7 or 1.8; or, as in N° 2. the rigidity is nearly in the duplicate ratio of the diameter of the rope. When the cord is much used, its flexibility is increased, and n becomes equal to 1.5 or 1.4.

Chap. IV. *On the Nature and Advantages of Fly Wheels.*

383. A fly, in mechanics, is a heavy wheel or cylinder which moves rapidly upon its axis, and is applied to machines for the purpose of rendering uniform a desultory or reciprocating motion, arising either from the nature of the machinery, from an inequality in the resistance to be overcome, or from an irregular application of the impelling power. When the first mover is inanimate, as wind, water, and steam, an inequality of force obviously arises from a variation in the velocity of the wind, from an increase or decrease of water occasioned by sudden rains, or from an augmentation or diminution of the steam in the boiler, produced by a variation in the heat of the furnace; and accordingly various methods have been adopted for regulating the action of these variable powers. The same inequality of force obtains when machines are moved by horses or men. Every animal exerts its greatest strength when first set to work. After pulling for some time, its strength will be impaired; and when the resistance is great, it will take frequent though short relaxations, and then commence its labour with renovated vigour. These intervals of rest and vigorous exertion must always produce a variation in the velocity of the machine, which ought particularly to be avoided, as being detrimental to the communicating parts as well as the performance of the machine, and injurious to the animal which is employed to draw it. But if a fly, consisting either of cross bars, or a massy circular rim, be connected with the machinery, all these inconveniences will be removed. As every fly wheel must revolve with great rapidity, the momentum of its circumference must be very considerable, and will consequently resist every attempt either to accelerate or retard its motion. When the machine therefore has been put in motion, the fly wheel will be whirling with an uniform celerity, and with a force capable of continuing that celerity when there is any relaxation in the impelling power. After a short rest the animal renews his efforts; but the machine is now moving with its former velocity, and these fresh efforts will have a tendency to increase that velocity. The fly, however, now acts as a resisting power, receives the greatest part of the superfluous motion, and causes the machinery to preserve its original celerity. In this way the fly secures to the engine an uniform motion, whether the animal takes occasional relaxations or exerts his force with redoubled ardour.

384. We have already observed that a desultory or variable motion frequently arises from the inequality of the resistance, or work to be performed. This is particularly manifest in thrashing mills, on a small scale, which are driven by water. When the corn is laid unequally on

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on the feeding board, so that too much is taken in by the fluted rollers, this increase of resistance instantly affects the machinery, and communicates a desultory or irregular motion even to the water wheel or first mover. This variation in the velocity of the impelling power may be distinctly perceived by the ear in a calm evening when the machine is at work. The best method of correcting these irregularities is to employ a fly wheel, which will regulate the motion of the machine when the resistance is either augmented or diminished. In machines built upon a large scale there is no necessity for the interposition of a fly, as the *inertia* of the machinery supplies its place, and resists every change of motion that may be generated by an unequal admission of the corn.

385. A variation in the velocity of engines arises also from the nature of the machinery. Let us suppose that a weight of 1000 pounds is to be raised from the bottom of a well 50 feet, by means of a bucket attached to an iron chain which winds round a barrel or cylinder, and that every foot length of this chain weighs two pounds. It is evident that the resistance to be overcome in the first moment is 1000 pounds added to 50 pounds the weight of this chain, and that this resistance diminishes gradually as the chain coils round the cylinder, till it is only 1000 pounds when the chain is completely wound up. The resistance therefore decreases from 1050 to 1000 pounds; and if the impelling power is inanimate, the velocity of the bucket will gradually increase; but if an animal is employed, it will generally proportion its action to the resisting load, and must therefore pull with a greater or less force according as the bucket is near the bottom or top of the well. In this case, however, the assistance of a fly may be dispensed with, because the resistance diminishes uniformly, and may be rendered constant by making the barrel conical, so that the chain may wind upon the part nearest the vertex at the commencement of the motion, the diameter of the barrel gradually increasing as the weight diminishes. In this way the variable resistance will be equalized much better than by the application of a fly wheel, for the fly having no motion of its own must necessarily waste the impelling power.

386. Having thus pointed out the chief causes of variation in the velocity of machines, and the method of rendering it uniform by the intervention of fly wheels, the utility, and in some instances the necessity, of this piece of mechanism, may be more obviously illustrated by shewing the propriety of their application in particular cases.

387. In the description of Vauloue's pile engine *, the reader will observe a striking instance of the utility of fly wheels. The ram Q is raised between the guides *b b* by means of horses acting against the levers S, S; but as soon as the ram is elevated to the top of the guides, and discharged from the follower G, the resistance against which the horses have been exerting their force is suddenly removed, and they would instantaneously tumble down, were it not for the fly O. This fly is connected with the drum B by means of the trundle X, and as it is moving with a very great force, it opposes a sufficient resistance to the action of the horses, till the ram is again taken up by the follower.

* See Part III. Plate CCCXXIX fig. 1.

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388. When machinery is driven by a single-stroke steam engine, there is such an inequality in the impelling power, that for two or three seconds it does not act at all. During this interval of inactivity the machinery would necessarily stop, were it not impelled by a massy fly wheel of a great diameter, revolving with rapidity, till the moving power again resumes its energy.

389. If the moving power is a man acting with a handle or winch, it is subject to great inequalities. The greatest force is exerted when the man pulls the handle upwards from the height of his knee, and he acts with the least force when the handle being in a vertical position is thrust from him in a horizontal direction. The force is again increased when the handle is pushed downwards by the man's weight, and it is diminished when the handle being at its lowest point is pulled towards him horizontally. But when a fly is properly connected with the machinery, these irregular exertions are equalized, the velocity becomes uniform, and the load is raised with an equable and steady motion.

390. In many cases, where the impelling force is alternately augmented and diminished, the performance of the machine may be increased by rendering the resistance unequal, and accommodating it to the inequalities of the moving power. Dr Robison observes that "there are some beautiful specimens of this kind of adjustment in the mechanism of animal bodies."

Besides the utility of fly wheels as regulators of machinery, they have been employed for accumulating or collecting power. If motion is communicated to a fly wheel by means of a small force, and if this force is continued till the wheel has acquired a great velocity, such a quantity of motion will be accumulated in its circumference, as to overcome resistances and produce effects which could never have been accomplished by the original force. So great is this accumulation of power; that a force equivalent to 20 pounds applied for the space of 37 seconds to the circumference of a cylinder 20 feet diameter, which weighs 4713 pounds, would, at the distance of one foot from the centre, give an impulse to a musket ball equal to what it receives from a full charge of gunpowder. In the space of six minutes and 10 seconds, the same effect would be produced if the cylinder was driven by a man who constantly exerted a force of 20 pounds at a winch one foot long (D).

391. This accumulation of power is finely exemplified in the *sling*. When the thong which contains the stone is swung round the head of the slinger, the force of the hand is continually accumulating in the revolving stone, till it is discharged with a degree of rapidity which it could never have received from the force of the hand alone. When a stone is projected from the hand itself, there is even then a certain degree of force accumulated, though the stone only moves through the arch of a circle. If we fix the stone in a opening at the

(D) This has been demonstrated by Mr Atwood. See his Treatise on Rectilineal and Rotatory Motion.

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extremity of a piece of wood two feet long, and discharge it in the usual way, there will be more force accumulated than with the hand alone, for the stone describes a larger arch in the same time, and must therefore be projected with greater force.

392. When coins or medals are struck, a very considerable accumulation of power is necessary, and this is effected by means of a fly. The force is first accumulated in weights fixed in the end of the fly. This force is communicated to two levers, by which it is farther condensed; and from these levers it is transmitted to a screw, by which it suffers a second condensation. The stamp is then impressed on the coin or metal by means of this force, which was first accumulated by the fly, and afterwards augmented by the intervention of two mechanical powers.

393. Notwithstanding the great advantage of fly wheels, both as regulators of machines and collectors of power, their utility wholly depends upon the position which is assigned them relative to the impelled and working points of the engine. For this purpose no particular rules can be laid down, as their positions depend altogether on the nature of the machinery. We may observe however, in general, that when fly wheels are employed to regulate machinery, they should be near the impelling power; and when used to accumulate force in the working point they should not be far distant from it. In hand-mills for grinding corn, the fly is for the most part very injudiciously fixed on the axis to which the winch is attached; whereas it should always be fastened to the upper millstone so as to revolve with the same rapidity. In the first position indeed it must equalize the varying efforts of the power which moves the winch; but when it is attached to the turning millstone, it not only does this, but contributes very effectually to the grinding of the corn.

Description of the conical pendulum. Fig. 8.

394. A new kind of fly, called a conical pendulum has been ingeniously employed by Mr Watt for procuring a determinate velocity at the working point of his steam-engine. It is represented in fig. 8. where AB is a vertical axis moving upon pivots, and driven by means of a rope passing from the axis of the large fly over the sheave EF. The large balls M, N are fixed to the rods NG, MH, which have an angular motion round P, and are connected by joints at G and H, with the rods GK, HK attached to the extremity of the lever KL whose centre of motion is L, and whose other extremity is connected with the cock which admits the steam into the cylinder. The frames CD and QR prevent the balls from receding too far from the axis, or from approaching too near it. Now when this conical pendulum is put in motion, the centrifugal force of the balls M, N makes them recede from the axis AB. In consequence of this recess, the points C, H, K are depressed, and the other extremity of the lever is raised; and the cock admits a certain quantity of steam into the cylinder. When the velocity of the fly is by any means increased, the balls recede still farther from the axis, the extremity of the lever is raised higher, and the cock closes a little and diminishes the supply of steam. From this diminution in the impelling power, the velocity of the fly and the conical pendulum decreases, and the balls resume their former position. In this way, when there is any increase or diminution in the velocity of the fly, the corresponding increase or diminution in the centrifugal force of the balls raises or depresses the arm of the lever, admits a greater or a less quantity of steam into the cylinder, and restores to the engine its former velocity.

Chap. V. *On the Teeth of Wheels, and the Wipers of Stampers.*

395. In the construction of machines, we must not only attend to the form and number of their parts, but also to the mode by which they are to be connected. It would be easy to shew, did the limits of this article permit it, that, when one wheel impels another, the impelling power will sometimes act with greater and sometimes with less force, unless the teeth of one or both of the wheels be parts of a curve generated after the manner of an epicycloid by the revolution of one circle along the convex or concave side of another. It may be sufficient to shew, that, when one wheel impels another by the action of epicycloidal teeth, their motion will be uniform. Let the wheel CD drive the wheel AB by means of the epicycloidal teeth mp, nq, or, acting upon the infinitely small pins or spindles a, b, c; and let the epicycloids mp, nq, &c. be generated by the circumference of the wheel AB, rolling upon the convex circumference of the wheel CD. From the formation of the epicycloid it is obvious that the arch ab is equal to mn, and the arch ac to mo; for during the formation of the part nb of the epicycloid nq, every point of the arch ab is applied to every point of the arch mn, and the same happens during the formation of the part co of the epicycloid or. Let us now suppose that the tooth mp begins to act on the pin a, and that b, c are successive positions of the pin a after a certain time; then, nq, or will be the positions of the tooth mp after the same time; but $ab = mn$ and $ac = mo$, therefore the wheels AB, CD, when the arch is driven by epicycloidal teeth, move through equal spaces in equal times, that is, the force of the wheel CD, and the velocity of the wheel AB, are always uniform. Fig. 9.

396. In illustrating the application of this property of the epicycloid, which was discovered by Olaus Roemer the celebrated Danish astronomer, we shall call the small wheel the *pinion*, and its teeth the *leaves* of the pinion. The line which joins the centre of the wheel and pinion is called the *line of centres*. There are three different ways in which the teeth of one wheel may drive another, and each of these modes of action requires a different form for the teeth.

1. When the action is begun and completed after the teeth have passed the line of centres.

2. When the action is begun and completed before they reach the line of centres.

3. When the action is carried on, on both sides of the line of centres.

First mode of action. Plate CCCXXIV. fig. 1.

397. 1. The first of these modes of action is represented in fig. 1. where B is the centre of the wheel (D), A that of the pinion, and AB the line of centres. It is evident from the figure, that the part b of the tooth ab of the wheel, does not act on the leaf m of the pinion till they arrive at the line of centres AB; and that all the action is carried on after they have passed this line, and is completed when the leaf m comes into the situation n. When this mode of action is adopted, the acting faces of

(D) In figs. 1, 2, 3, 4, the letter B is supposed to be placed at the centre of the wheels.

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398. But when one circle rolls within another whose diameter is double that of the rolling circle, the line generated by any point of the latter is a *straight line*, tending to the centre of the larger circle. Therefore, if the generating circle above mentioned should be taken with its diameter equal to the radius of the pinion, and be made to roll upon the concave superficies *a d h* of the pinion, it will generate a straight line tending to the pinion's centre, which will be the form of the faces of its leaves; and the teeth of the wheel will be exterior epicycloids, formed by a generating circle, whose diameter is equal to the radius of the pinion, rolling upon the convex superficies *o d p* of the wheel. This rectilineal form of the teeth is exhibited in fig. 2. and is perhaps the most advantageous, as it requires less trouble, and may be executed with greater accuracy, than if the epicycloidal form had been employed, though the teeth are evidently weaker than those in fig. 1.; it is recommended both by De la Hire and Camus as particularly advantageous in clock and watch-work. Fig. 2.

Fig. 1. 399. The attentive reader will perceive from fig. 1. that in order to prevent the teeth of the wheel from acting upon the leaves of the pinion before they reach the line of centres AB; and that one tooth of the wheel may not quit the leaf of the pinion till the succeeding tooth begins to act upon the succeeding leaf, there must be a certain proportion between the number of leaves in the pinion and the number of teeth in the wheel, or between the radius of the pinion and the radius of the wheel, when the distance of the leaves AB is given. But in machinery the number of leaves and teeth is always known from the velocity which is required at the working point of the machine: It becomes a matter therefore of great importance to determine with accuracy the relative radii of the wheel and pinion.

Relative size of the wheel and pinion. 400. For this purpose, let A, fig. 2. be the pinion having the acting faces of its leaves straight lines tending to the centre, and B the centre of the wheel. AB will be the distance of their centres. Then as the tooth C is supposed not to act upon the leaf A*m* till it arrives at the line AB, it ought not to quit A*m* till the following tooth F has reached the line AB. But since the tooth always acts in the direction of a line drawn perpendicular to the face of the leaf A*m* from the point of contact, the line CH, drawn at right angles to the face of the leaf A*m*, will determine the extremity of the tooth CD, or the last part of it which should act upon the leaf A*m*, and will also mark out CD for the depth of the tooth. Now, in order to find AH, HB, and CD, put a for the number of teeth in the wheel, b for the number of leaves in the pinion, c for the distance of the pivots A and B, and let x be the radius of the wheel, and y that of the pinion. Then, since the circumference of the wheel is to the circumference of the pinion, as the number of teeth in the one to the number of leaves in the other, and as the circumferences of circles are proportional to their radii, we shall have $a : b = x : y$, then by composition (Eucl. v. 18.) $a+b : b = c : y$ (c being equal to $x+y$), and consequently the radius of the pinion, viz. $y = \frac{c\,b}{a+b}$; then by inverting the first analogy, we have $b : a = y : x$, and consequently the radius of the wheel, viz. $x = \frac{a\,y}{b}$; y being now a known number.

Now, in the triangle AHC, right-angled at C, the side AH is known, and likewise all the angles (HAC being equal to $\frac{360}{b}$); the side AC, therefore, may be found by plain trigonometry. Then, in the triangle ACB, the $\angle$CAB, equal to HAC, is known, and also the sides AB, AC, which contain it; the third side, therefore, viz. CB, may be determined; from which DB, equal to HB, already found, being subtracted, there will remain CD for the depth of the teeth. When the action is carried on after the line of centres, it often happens that the teeth will not work in the hollows of the leaves. In order to prevent this, the $\angle$ CBH must always be greater than half the $\angle$ HBP. The $\angle$ HBP is equal to 360 degrees, divided by the number of teeth in the wheel, and CBH is easily found by plane trigonometry.

401. If the teeth of wheels and the leaves of pinions be formed according to the directions already given, they will act upon each other, not only with uniform force, but nearly without friction. The one tooth rolls upon the other, and neither slides nor rubs to such a degree as to retard the wheels, or wear their teeth. But as it is impossible in practice to give that perfect curvature to the faces of the teeth which theory requires, a quantity of friction will remain after every precaution has been taken in the formation of the communicating parts.

402. 2. The second mode of action is not so advantageous as that which we have been considering, and should, if possible, always be avoided. It is represented in fig. 3. where A is the centre of the pinion, B that of the wheel, and AB the line of centres. It is evident from the figure, that the tooth C of the wheel acts upon the leaf D of the pinion before they arrive at the line BA; that it quits the leaf when they reach this line, and have assumed the position of E and F; and that the tooth c works deeper and deeper between the leaves of the pinion, the nearer it comes to the line of centres. From this last circumstance a considerable quantity of friction arises, because the tooth C does not, as before, roll upon the leaf D, but slides upon it; and from the same cause the pinion soon becomes foul, as the dust which lies upon the acting faces of the leaves is pushed into the interjacent hollows. One advantage, however, attends this mode of action: It allows us to make the teeth of the large wheel rectilineal, and thus renders the labour of the mechanic less, and the accuracy of his work greater, than if they had been of a curvilineal form. If the teeth C, E, therefore of the wheel BC are made rectilineal, having their surfaces directed to the wheel's centre, the acting faces of the leaves D, F, &c. must be epicycloids formed by a generating circle, whose diameter is equal to the radius B o of the circle $o\,p$, rolling upon the circumference $m\,n$ of the pinion A. But if the teeth of the wheel and the leaves of the pinion are made curvilineal as in the figure, the faces of the teeth of the wheel must be portions of an interior epicycloid formed by any generating Second mode of action. Fig. 3.

[...actical ...hanics.] rating circle rolling within the concave superficies of the circle $o\,p$, and the faces of the pinion's leaves must be portions of an exterior epicycloid produced by rolling the same generating circle upon the convex circumference $m\,n$ of the pinion.

[...rd mode ...ction. ... 4.] 403. 3. The third mode of action, which is represented in fig. 4. is a combination of the two first modes, and consequently partakes of the advantages and disadvantages of each. It is evident from the figure that the portion $e\,b$ of the tooth acts upon the part $b\,c$ of the leaf till they reach the line of centres AB, and that the part $e\,d$ of the tooth acts upon the portion $b\,a$ of the leaf after they have passed this line. Hence the acting parts $e\,h$ and $b\,c$ must be formed according to the directions given for the first mode of action, and the remaining parts $e\,d$, $b\,a$, must have that curvature which the second mode of action requires; consequently $e\,h$ should be part of an interior epicycloid formed by any generating circle rolling on the concave circumference $m\,n$ of the wheel, and the corresponding part $b\,c$ of the leaf should be part of an exterior epicycloid formed by the same generating circle rolling upon b EO, the convex circumference of the pinion: the remaining bart $c\,d$ of the tooth should be a portion of an exterior epicycloid, engendered by any generating circle rolling upon e L, the concave superficies of the wheel: and the corresponding part $b\,a$ of the leaf should be part of an interior epicycloid described by the same generating circle, rolling along the concave side b EO of the pinion. As it would be extremely troublesome, however, to give this double curvature to the acting faces of the teeth, it will be proper to use a generating circle, whose diameter is equal to the radius of the wheel BC, for describing the interior epicycloid $e\,h$ and the exterior one $b\,c$, and a generating circle, whose diameter is equal to AC, the radius of the pinion, for describing the interior epicycloid $b\,a$, and the exterior one $e\,d$. In this case the two interior epicycloids $e\,h$, $b\,a$, will be straight lines tending to the centres B and A, and the labour of the mechanic will by this means be greatly abridged.

[...lative ...meters the ...eel and ...ion.] 404. In order to find the relative diameters of the wheel and pinion, when the number of teeth in the one and the number of leaves in the other are given, and when the distance of their centres is also given, and the ratio of ES to CS, let a be the number of teeth in the wheel, b the number of leaves in the pinion, c the distance of the pivots A, B, and let m be to n as ES to CS, then the arch ES, or $\angle$ SAE, will be equal to $\frac{360^\circ}{b}$, and LD, or $\angle$ LBD, will be equal to $\frac{360^\circ}{a}$. But ES : CS$=m:n$; consequently LD : LC$=m:n$, therefore (Eucl. vi. 16.) LC$\times m=$LD$\times n$, and LC$=\frac{\text{LD}\times n}{m}$; but LD is equal to $\frac{360}{a}$, therefore by substitution LC$=\frac{360\times n}{am}$.

Now, in the triangle APB, AB is known, and also PB, which is the cosine of the angle ABD, PC being perpendicular to DB; AP or the radius of the pinion therefore may be found by plane trigonometry. The reader will observe that the point P marks out the parts of the tooth D and the leaf SP where they commence their action; and the point I marks out the parts where their mutual action ceases (E); AP therefore is the proper radius of the pinion, and BI the proper radius of the wheel, the parts of the tooth L without the point I, and of the leaf SP without the point P, being superfluous. Now, to find BI, we have ES : CS$=m:n$, and CS$=\frac{\text{ES}\times n}{m}$; but ES was shewn to be $=\frac{360}{b}$, therefore, by substitution, CS$=\frac{360\times n}{b\,m}$. Now the arch ES, or $\angle$ EAS, being equal to $\frac{360}{b}$, and CS, or $\angle$CAS, being equal to $\frac{360\times n}{b\,m}$, their difference EC, or the angle EAC, will be equal to $\frac{360}{b}-\frac{360\times n}{b\,m}$, or $\frac{360^\circ\times\overline{m-n}}{b\,m}$. The $\angle$ EAC being thus found, the triangle EAB, or IAB, which is almost equal to it, is known, because AB is given, and likewise AI, which is equal to the cosine of the angle IAB, AC being radius, and AIC being a right angle, consequently IB the radius of the wheel may be found by trigonometry. It was formerly shewn that AC, the radius of what is called the primitive pinion, was equal to $\frac{c\,b}{a+b}$, and that BC the radius of the primitive wheel was equal to $\frac{\text{AC}\times a}{b}$. If then we subtract AC or AS from AP, we shall have the quantity SP which must be added to the radius of the primitive pinion, and if we take the difference of BC (or BL) and DE, the quantity LE will be found, which must be added to the radius of the primitive wheel. We have all along supposed that the wheel drives the pinion, and have given the proper form of the teeth upon this supposition. But when the pinion drives the wheel, the form which was given to the teeth of the wheel in the first case, must in this be given to the leaves of the pinion; and the shape which was formerly given to the leaves of the pinion must now be transferred to the teeth of the wheel.

405. Another form for the teeth of wheels, different from any which we have mentioned, has been recommended by Dr Robison. He shews that a perfect uniformity of action may be secured, by making the acting faces of the teeth involutes of the wheel's circumference, which are nothing more than epicycloids, the centres of whose generating circles are infinitely distant. Thus, in fig. 1. let AB be a portion of the wheel on which [Form of the teeth according to Dr Robison.]

(E) The letter L marks the intersection of the line BL with the arch $e\,m$, and the letter E the intersection of the arch b O with the upper surface of the leaf m. The letters D and S correspond with L and E respectively, and P with I.

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Fig. 5.

which the tooth is to be fixed, and let A *p a* be a thread lapped round its circumference, having a loop hole at its extremity *a*. In this loop hole fix the pin *a*, and with it describe the curve or *involute a b c d e h*, by unlapping the thread gradually from the circumference A *p m*. This curve will be the proper shape for the teeth of a wheel whose diameter is AB. Dr Robison observes, that as this form admits of several teeth to be acting at the same time (twice the number that can be admitted in M. de la Hire's method), the pressure is divided among several teeth, and the quantity upon any one of them is so diminished, that those dents and impressions which they unavoidably make upon each other are partly prevented. He candidly allows, however, that the teeth thus formed are not completely free from sliding and friction, though this slide is only $\frac{1}{60}$th of an inch, when a tooth three inches long fixed on a wheel ten feet in diameter drives another wheel whose diameter is two feet. *Append. to Ferguson's Lectures.*

406. *On the Formation of Exterior and Interior Epicycloids, and on the Disposition of the Teeth on the Wheel's Circumference.*

Mechanical method of forming epicycloids.

Nothing can be of greater importance to the practical mechanic, than to have a method of drawing epicycloids with facility and accuracy; the following, we trust, is the most simple mechanical method that can be employed.—Take a piece of plain wood GH, fig. 6. and fix upon it another piece of wood E, having its circumference *m b* of the same curvature as the circular base upon which the generating circle AB is to roll. When the generating circle is large, the segment B will be sufficient: in any part of the circumference of this segment, fix a sharp pointed nail *a*, sloping in such a manner that the distance of its point from the centre of the circle may be exactly equal to its radius; and fasten to the board GH a piece of thin brass, or copper, or tinplate, *a b*, distinguished by the dotted lines. Place the segment B in such a position that the point of the nail *a* may be upon the point *b*, and roll the segment towards G, so that the nail *a* may rise gradually, and the point of contact between the two circular segments may advance towards *m*; the curve *a b* described upon the brass plate will be an accurate exterior epicycloid. In order to prevent the segments from sliding, their peripheries should be rubbed with rosin or chalk, or a number of small iron points may be fixed on the circumference of the generating segment. Remove, with a file, the part of the brass on the left hand of the epicycloid, and the remaining concave arch or gage *a b* will be a pattern tooth, by means of which all the rest may be easily formed. When an *interior epicycloid* is wanted, the concave side of its circular base must be used. The method of describing it is represented in fig. 7. where CD is the generating circle, F the concave circular base, MN the piece of wood on which this base is fixed, and *c d* the interior epicycloid formed upon the plate of brass, by rolling the generating circle C, or the generating segment D, towards the right hand. The *cycloid*, which is useful in forming the teeth of *rack-work*, is generated precisely in the same manner, with this difference only, that the base on which the generating circle rolls must be a straight line.

Fig. 6.

Fig. 7.

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Disposition of the tooth.

In order that the teeth may not embarrass one another before their action commences, and that one tooth may begin to act upon its corresponding leaf of the pinion, before the preceding tooth has ceased to act upon the preceding leaf, the height, breadth, and distance of the teeth must be properly proportioned. For this purpose the pitch-line or circumference of the wheel, which is represented in fig. 2. and 3. by the dotted arches, must be divided into as many equal spaces as the number of teeth which the wheel is to carry. Divide each of these spaces into 16 equal parts; allow 7 of these for the greatest breadth of the teeth, and 9 for the distance between each; or the distance of the teeth may be made equal to their breadth. If the wheel drive a trundle, each space should be divided into 7 equal parts, and 3 of these allotted for the thickness of the tooth, and $3\frac{2}{7}$ for the diameter of the cylindrical stave of the trundle. If each of the spaces already mentioned, or if the distance between the centres of each tooth, be divided into three equal parts, the height of the teeth must be equal to two of these. These distances and heights, however, vary according to the mode of action which is employed. The teeth should be rounded off at the extremities, and the radius of the wheel made a little larger than that which is deduced from the rules in Art. 400, 404. But when the pinion drives the wheel, a small addition should be made to the radius of the pinion.

On the Nature of Bevelled Wheels, and the method of giving an epicycloidal form to their Teeth.

Bevelled wheels.

407. The principle of bevelled wheels was pointed out by De la Hire, so long ago as the end of the 17th century. It consists in one fluted or toothed cone acting upon another, as is represented in fig. 8. where the cone OD drives the cone OC, conveying its motion in the direction OC. If these cones be cut parallel to their bases as at A and B, and if the two small cones between AB and O be removed, the remaining parts AC and BD may be considered as two bevelled wheels, and BD will act upon AC in the very same manner, and with the same effect, that the whole cone OD acted upon the whole cone OC. If the section be made nearer the bases of the cones, the same effect will be produced: this is the case in fig. 9. where CD and DE are but very small portions of the imaginary cones ACD and ADE.

Fig. 8.

Fig. 9.

408. In order to convey motion in any given direction, and determine the relative size and situation of the wheels for this purpose, let AB, fig. 10. be the axis of a wheel, and CD the given direction in which it is required to convey the motion by means of a wheel fixed upon the axis AB, and acting upon another wheel fixed on the axis CD, and let us suppose that the axis CD must have four times the velocity of AB, or must perform four revolutions while AB performs one. Then the number of teeth in the wheel fixed upon AB must be four times greater than the number of teeth in the wheel fixed upon CD, and their radii must have the same proportion. Draw *c d* parallel to CD at any convenient distance, and draw *a b* parallel to AB at four times that distance, then the lines *i m* and *i n* drawn perpendicular to AB and CD respectively, will mark the situation and size of the wheels required. In this

Fig. 10.

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this case the cones are O $n i$ and O $m i$, and $s r n i$, $r p m i$, are the portions of them that are employed.

On the formation of teeth.

The formation of the teeth of bevelled wheels is more difficult than one would at first imagine. The teeth of such wheels, indeed, must be formed by the same rules which have been given for other wheels; but since different parts of the same tooth are at different distances from the axis, these parts must have the curvature of their acting surfaces proportioned to that distance. Thus, in fig. 10. the part of the tooth at r must be more incurvated than the part at i, as is evident from the inspection of fig. 9.; and the epicycloid for the part i must be formed by means of circles whose diameters are $i m$ and Ff, while the epicycloid for the part r must be generated by circles whose diameters are C n and D d.

409. Let us suppose a plane to pass through the points O, A, D; the lines AB, AO, will evidently be in this plane, which may be called the *plane of centres*. Now, when the teeth of the wheel DE, which is supposed to drive CD the smallest of the two, commence their action on the teeth of CD, when they arrive at the plane of centres, and continue their action after they have passed this plane, the curve given to the teeth of CD at C, should be a portion of an interior epicycloid formed by any generating circle rolling on the concave superficies of a circle whose diameter is twice C n perpendicular to CA, and the curvature of the teeth at i should be part of a similar epicycloid, formed upon a circle, whose diameter is twice $i m$. The curvature of the teeth of the wheel DE at D, should be part of an exterior epicycloid formed by the same generating circle rolling upon the concave circumference of a circle whose diameter is twice D d perpendicular to DA; and the epicycloid for the teeth at F is formed in the same way, only instead of twice D d, the diameter of the circle must be twice Ff. When any other mode of action is adopted, the teeth are to be formed in the same manner that we have pointed out for common wheels, with this difference only, that different epicycloids are necessary for the parts F and D. It may be sufficient, however, to find the form of the teeth at F, as the remaining part of the tooth may be shaped by directing a straight ruler from different points of the epicycloid at F to the centre A, and filling the tooth till every part of its acting surface coincide with the side of the ruler. The reason of this operation will be obvious by attending to the shape of the tooth in fig. 8. When the small wheel CD impels the large one DE, the epicycloids which were formerly given to CD must be given to DE, and those which were given to DE must be transferred to CD.

Fig. 8.

Of crown wheels.

410. The wheel represented in fig. 11. is sometimes called a crown wheel, though it is evident from the figure that it belongs to that species of wheels which we have just been considering; for the acting surfaces of the teeth both of the wheel MB and of the pinion EDG are directed to C the common vertex of the two cones CMB, CEG. In this case the rules for bevelled wheels must be adopted, in which AS is to be considered as the radius of the wheel for the profile of the tooth at A, and MN as its radius for the profile of the tooth at M; and the epicycloids thus formed will be the sections or profiles of the teeth in the direction MP, at right angles to MC the surfaces of the cone. When the vertex C of the cone MCG approaches to N till it be in the same plane with the points M, G, some of the curves will be cycloids and others involutes, as in the case of rack-work, for then the cone CEG will revolve upon a plane surface. *Appendix to Ferguson's Lectures.*

Fig. 11.

Sect. II. *On the Wipers of Stampers, &c. the Teeth of Rack-work, &c. &c.*

Fig. 12.

411. In fig. 12. let AB be the wheel which is employed to elevate the rack C, and let their mutual action not commence till the acting teeth have reached the line of centres AC. In this case C becomes as it were the pinion or wheel driven, and the acting faces of its teeth must be *interior epicycloids* formed by any generating circle rolling within the circumference $p q$; but as $p q$ is a straight line, these interior epicycloids will be *cycloids*, or curves generated by a point in the circumference of a circle, rolling upon a straight line or plane surface. The acting face $o p$, therefore, will be part of a *cycloid* formed by any generating circle, and $m n$, the acting face of the teeth of the wheel, must be an *exterior* epicycloid produced by the same generating circle rolling on $m r$ the convex surface of the wheel. If it is required to make $o p$ a straight line, as in the figure, them $m n$ must be an *involute* of the circle $m r$ formed in the manner represented in fig. 5.

412. Fig. 12. likewise represents a wheel depressing the rack c when the third mode of action is used. In this case also c becomes the pinion, and DE the wheel; $e h$ therefore must be part of an interior epicycloid formed by any generating circle rolling on the concave side $e x$ of the wheel, and $b c$ must be an exterior epicycloid produced by the same generating circle rolling upon the circumference of the rack. The remaining part $e d$ of the teeth of the wheel must be an exterior epicycloid described by any generating circle moving upon the convex side $e x$, and $b a$ must be an interior epicycloid engendered by the same generating circle rolling within the circumference of the rack. But as the circumference of the rack is in this case a straight line, the exterior epicycloid $b e$ and the interior one $b a$ will be cycloids formed by the same generating circles which are employed in describing the other epicycloids. Since it would be difficult, however, as has already been remarked, to give this compound curvature to the teeth of the wheel and rack, we may use a generating circle whose diameter is equal to D x the radius of the wheel, for describing the interior epicycloid $e h$, and the exterior one $b e$; and a generating circle whose diameter is equal to the radius of the rack, for describing the interior epicycloid $a b$, and the exterior one $d e$; $a b$ and $e h$, therefore, will be straight lines, and $b e$ will be a cycloid, and $d e$ an involute of the circle $e x$, the radius of the rack being infinitely great.

413. In the same manner may the form of the teeth of rack-work be determined, when the second mode of action is employed, and when the teeth of the wheel or rack are circular or rectilineal. But if the rack be part of a circle, it must have the same form of its teeth as that of a wheel of the same diameter with the circle of which it is a part.

In

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Proper form of wipers.

In machinery, where large weights are to be raised, such as falling-mills, mills for pounding ore, &c. or where large pistons are to be elevated by the arms of levers, it is of the greatest consequence that the power should raise the weight with an uniform force and velocity; and this can be effected only by giving a proper form to the wiper.

Now there are two cases in which this uniformity of motion may be required, and each of these demands a different form for the communicating parts. 1. When the weight is to be raised vertically, as the piston of a pump, &c. 2. When the weight to be raised or depressed moves upon a centre, and rises or falls in the arch of a circle, such as the sledge hammer in a forge, &c.

Fig. 13.

414. 1. Let AH be a wheel moved by any power which is sufficient to raise the weight MN by its extremity O, from O to *e*, in the same time that the wheel moves round one-fourth of its circumference, it is required to fix upon its rim a wing OBCDEH which shall produce this effect with an uniform effect. Divide the quadrant OH into any number of equal parts O *m*, *m n*, &c. the more the better, and *o e* into the same number *o b*, *b c*, *c d*, &c. and through the points *m*, *n*, *p*, H draw the indefinite lines AB, AC, AD, AE, and make AB equal to A*b*, AC to A*c*, AD to A*d*, and AE to A*e*; then through the points O, B, C, D, E, draw the curve OBCDE, which is a portion of the spiral of Archimedes, and will be the proper form for the wiper or wing OHE. It is evident that when the point *m* has arrived at O, the extremity of the weight will have arrived at *b*; because AB is equal to A *b*, and for the same reason, when the points *n*, *p*, H have successively arrived at O, the extremity of the weight will have arrived at the corresponding points *c*, *d*, *e*. The motion therefore will be uniform, because the space described by the weight is proportional to the space described by the moving power, O *b* being to O *c* as O *m* to O *n*. If it be required to raise the weight MN with an accelerated or retarded motion, we have only to divide the line O *e* according to the law of acceleration or retardation, and divide the curve OBCDE as before.

When the weight rises in the arch of a circle. Fig. 14.

415. 2. When the lever moves upon a centre, the weight will rise in the arch of a circle, and consequently a new form must be given to the wipers or wings. Let AB, fig. 14. be a lever lying horizontally, which it is required to raise uniformly through the arch BC into the position AC, by means of the wheel BFH furnished with the wing BNOP, which acts upon the extremity C of the lever; and let it be required to raise it through BC in the same time that the wheel BFH moves through one-half of its circumference; that is, while the point M moves to B in the direction MFB. Divide the chord CB into any number of equal parts, the more the better, in the points 1, 2, 3, and draw the lines 1 *a* 2 *b* 3 *c* parallel to AB, or a horizontal line passing through the point B, and meeting the arch BC in the points *a*, *b*, *c*. Draw the lines CD, *a* D, *b* D, *c* D, and BD cutting the circle BFH in the points *m*, *n*, *o*, *p*.

Having drawn the diameter BM, divide the semicircle BFM into as many equal parts as the chord CB, in the points *q*, *s*, *u*. Take B *m*, and set it from *q* to *r*: Take B *n* and set it from *s* to *t*: Take B *o* and set it from *u* to *v*, and lastly set B *p* from M to E. Through the points *r*, *t*, *v*, E, draw the indefinite lines DN, DO, DP, DQ, and make DN equal to D *c*; DO equal to D *b*; DP equal to D *a*; and DQ equal to DC. Then through the points Q, P, O, N, B, draw the spiral B, N, O, P, Q, which will be the proper form for the wing of the wheel when it moves in the direction EMB.

That the spiral BNO will raise the lever AC, with an uniform motion, by acting upon its extremity *c*, will appear from the slightest attention to the construction of the figure. It is evident, that when the point *q* arrives at B, the point *r* will be in *m*, because B *m* is equal to *q r*, and the point N will be at *c*, because DN is equal to D *c*; the extremity of the lever therefore, will be found in the point *c*, having moved through B *c*. In like manner, when the point *s* has arrived at B, the point *t* will be at *n*, and the point O, in *b*, where the extremity of the lever will now be found; and so on with the rest, till the point M has arrived at B. The point E will then be in *p*, and the point Q in C; so that the lever will now have the position AC, having moved through the equal heights B*c*, *c b*, *b a*, *a c*, (F) in the same time that the power has moved through the equal spaces *q* B, *s q*, *u s*, M *u*. The lever, therefore, has been raised uniformly, the ratio between the velocity of the power, and that of the weight, remaining always the same.

416. If the wheel D turn in a contrary direction, according to the letters MHB, we must divide the semicircle BH EM, into as many equal parts as the chord *c* B, viz. in the points *e*, *g*, *h*. Then, having set the arch B *m* from *e* to *d*, the arch B *n* from *g* to *f*, and the rest in a similar manner, draw through the points *d*, *f*, *h*, E, the indefinite lines DR, DS, DT, DQ: make DR equal to D *c*; DS equal to D *b*; DT equal to D *a*, and DQ equal to DC; and through the points B, R, S, T, Q, describe the spiral BRSTQ, which will be the proper form for the wing, when the wheel turns in the direction MEB. For, when the point *e* arrives at B, the point *d* will be in *m*, and R in *c*, where the extremity of the lever will now be found, having moved through B *c* in the same time that the power, or wheel, has moved through the division *e* B. In the same manner it may be shewn, that the lever will rise through the equal heights *c b*, *b a*, *a* C, in the same time that the power moves through the corresponding spaces *e g*, *g i*, *i* M. The motion of the lever, therefore, and also that of the power, are always uniform. Of all the positions that can be given to the point B, the most disadvantageous are those which are nearest the points F, H; and the most advantageous position is when the chord B *c* is vertical, and passes, when prolonged, through D, the centre

(F) The arches B *c*, *c b*, &c. are not equal; but the perpendiculars let fall from the points *c*, *a*, *b*, &c. upon the horizontal lines, passing through *a b*, &c. are equal, being proportional to the equal lines *c* 1, 1, 2. Eucl. VI. 2.

centre of the circle (G). In this particular case the two curves have equal bases, though they differ a little in point of curvature. The farther that the centre A is distant, the nearer do these curves resemble each other; and if it were infinitely distant, they would be exactly similar, and would be the spirals of Archimedes, as the extremity *c* would in this case rise perpendicularly.

It will be easily pereeived that 4, 6, or 8 wings may be placed upon the circumference of the circle, and may be formed by dividing into the same number of equal parts as the chord BC, $\frac{1}{4}$, $\frac{1}{6}$, or $\frac{1}{8}$ of the circumference, instead of the semicircle BFM.

That the wing BNO may not act upon any part of the lever between A and C, the arm AC should be bent; and that the friction may be diminished as much as possible, a roller should be fixed upon its extremity C. When a roller is used, however, a curve must always be drawn parallel to the spiral described according to the preceding method, the distance between it and the spiral being everywhere equal to the radius of the roller.

If it should be required to raise the roller with an accelerated or retarded motion, we have only to divide the chord BC, according to the degree of retardation or acceleration required, and the circle into the same number of equal parts as before.

417. As it is frequently more convenient to raise or depress weights by the extremity of a constant radius, furnished with a roller, instead of wings fixed upon the periphery of a wheel; we shall now proceed to determine the curve which must be given to the arm of the lever which is to be raised and depressed, in order that this elevation or depression may be effected with an uniform motion.

Let AB be a lever, which it is required to raise uniformly through the arch BC, into the position AC, by means of the arm or constant radius DE, moving upon D as a centre, in the same time that the extremity E describes the arch E*e*F. From the point C draw CH at right angles to AB, and divide it into any number of equal parts, suppose three, in the points 1, 2; and through the points 1, 2, draw 1 *a* 2 *b*, parallel to the horizontal line AB, cutting the arch CB in the points *a*, *b*, through which draw *a* A, *b* A. Upon D as a centre, with the distance DE, describe the arch E *i c* F, and upon A as a centre, with the distance AD, describe the arch *c* O D, cutting the arch E *i c* F in the point *c*. Divide the arches E *i c*, and F *s c*, each into the same number of equal parts as the perpendicular *c* H, in the points *k*, *i*, *s*, *m*, and through these points about the centre A, describe the arches *k z*, *i g*, *q r*, *m n*. Make *z x* and set it from *k* to *l*, and take *g f*, and set it from *i* to *h*. Take *r q* also, and set it from *s* to *t*, and set *n m* from *o* to *p*, and *d c* from *c* to O. Then through the points E, *l*, *h*, O, and O, *t*, *p*, F, draw the two curves E *l h* O, and O *t p* F, which will be the proper form that must be given to the arm of the lever. If the handle DE moves from E towards F, the curve EO must be used, but if in the contrary direction, we must employ the curve OF.

It is evident, that when the extremity E of the handle DE, has run through the arch E *k*, or rather E *l*, the point *l* will be in *k*, and the point *z* in *x*, because *x z* is equal to *k l*, and the lever will have the position A *b*. For the same reason, when the extremity E of the handle has arrived at *i*, the point *h* will be in *i*, and the point *g* in *f*, and the lever will be raised to the position A *a*. Thus it appears, that the motion of the power and the weight are always proportional. When a roller is fixed at E, a curve parallel to EO, or OF, must be drawn as formerly. See *Appendix to Ferguson's Lectures*.

Chap. VI. *On the First Movers of Machinery.*

418. The powers which are generally employed as the first movers of machines are water, wind, steam, and animal exertion. The mode of employing water as an impelling power has already been given at great length in the article Hydrodynamics. The application of wind to turn machinery will be discussed in the chapter on Windmills; and what regards steam will be more properly introduced into the article *Steam-Engine*. At present, therefore, we shall only make a few general remarks on the strength of men and horses; and conclude with a general view of the relative powers of the first movers of machinery. The following table contains the weight which a man is able to raise through a certain height in a certain time, according to different authors.

Table *of the Strength of Men, according to different authors.*

Number of pounds raised.	Height to which the weight is raised	Time in which it is raised.	Duration of the Work.	Names of the authors.
1000	180	60 minutes		Euler
60 } French.	1 } French.	1 second	8 hours	Bernouilli
25 } French.	220 } French.	145 seconds		Amontons
170 } French.	1 } French.	1 second	half an hour	Coulomb
1000	330	60 minutes		Desaguliers
1000	225	60 minutes		Smeaton
30	$3\frac{1}{2}$	1 second	10 hours	Emerson
29 or 30	2.45 feet.	1 second		Schulze

419.

(G) In the figure we have taken the point B in a disadvantageous position, because the intersections are in this case more distinct.

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Force of men according to Amontons.

419. According to Amontons, a man weighing 133 pounds French, ascended 62 feet French by steps in 34 seconds, but was completely exhausted. The same author informs us that a sawer made 200 strokes of 18 inches French each, with a force of 25 pounds, in 145 seconds; but that he could not have continued the exertion above three minutes.

According to Desaguliers.

420. It appears from the observations of Desaguliers, that an ordinary man can, for the space of ten hours, turn a winch with a force of 30 pounds, and with a velocity of two feet and a half per second; and that two men working at a windlass with handles at right angles to each other, can raise 70 pounds more easily than one man can raise 30. The reason of this is, that when there is only one man, he exerts variable efforts at different positions of the handle, and therefore the motion of the windlass is irregular; whereas in the case of two men, with handles at right angles, the effect of the one man is greatest when the effect of the other is least, and therefore the motion of the machine is more uniform, and will perform more work. Desaguliers also found, that a man may exert a force of 80 pounds with a fly when the motion is pretty quick, and that by means of a good common pump, he may raise a hogshead of water 10 feet high in a minute, and continue the exertion during a whole day.

Results of Coulomb's experiments.

421. A variety of interesting experiments upon the force of men were made by the learned M. Coulomb. He found that the quantity of action of a man who ascended stairs with nothing but his own weight, was double that of a man loaded with 223 pounds avoirdupois, both of them continuing the exertion for a day. In this case the total or *absolute effect* of the unloaded man is the greatest possible; but the *useful effect* which he produces is nothing. In the same way, if he were loaded to such a degree that he was almost incapable of moving, the useful effect would be nothing. Hence there is a certain load with which the man will produce the greatest useful effect. This load M. Coulomb found to be 173.8 pounds avoirdupois, upon the supposition that the man is to ascend stairs, and continue the exertion during a whole day. When thus loaded, the quantity of action exerted by the labourer is equivalent to 183.66 pounds avoirdupois raised through 3282 feet. This method of working is however attended with a loss of three-fourths of the total action of the workman.—It appears also from Coulomb's experiments, that a man going up stairs for a day raises 205 chiliogrammes (a chiliogramme is equal to three ounces five drams avoirdupois) to the height of a chiliometre (a chiliometre is equal to 39571 English inches); that a man carrying wood up stairs raises, together with his own weight, 109 chiliogrammes to one chiliometre;—that a man weighing 150 pounds French, can ascend by stairs three feet French in a second, for the space of 15 or 20 seconds; —that a man cultivating the ground performs $\frac{12}{20}$ as much labour as a man ascending stairs, and that his quantity of action is equal to 328 pounds avoirdupois raised through the space of 3282 feet;—that a man with a winch does $\frac{6}{8}$ as much as by ascending stairs;—and that in a pile-engine, a man by means of a rope drawn horizontally, raised for the space of five hours $55\frac{1}{7}$ pounds French through one foot French in a second.—When men walk on a horizontal road, Coulomb found that the quantity of action was a maximum when they were loaded, and that this maximum quantity of action is to that which is exerted by a man loaded with 190.25 pounds avoirdupois as 7 to 4.—The weight which a man ought to carry in order that the *useful effect* may be a maximum, is 165.3 pounds avoirdupois. When the workman, however, returns unloaded for a new burden, he must carry 200.7 pounds avoirdupois.

422. According to Dr Robison a feeble old man raised seven cubic feet of water$=437.5$ pounds avoirdupois, $11\frac{1}{2}$ feet high, in one minute, for eight or ten hours a day, by walking backwards and forwards on a lever;—and a young man weighing 135 pounds, and carrying 30 pounds, raised $9\frac{1}{4}$ cubic feet of water $=578.1$ pounds avoirdupois, $11\frac{1}{2}$ feet high, for 10 hours a day, without being fatigued.

423. From the experiments of Mr Buchanan, it appears that the forces exerted by a man pumping, acting at a winch, ringing and rowing, are as the numbers 1742, 2856, 3883, 4095.

On the strength of horses.

424. According to Desaguliers and Smeaton, the power of one horse is equal to the power of five men. Several French authors suppose a horse equal to seven men, while M. Schulze considers one horse as equivalent to 14 men.—Two horses, according to the experiment of Amontons, exerted a force of 150 pounds French, when yoked in a plough. According to Desaguliers, a horse is capable of drawing, with a force of 200 pounds, two miles and a half an hour, and of continuing this action eight hours in the day. When the force is 240 pounds he can work only six hours. It appears from Smeaton's reports, that by means of pumps a horse can raise 250 hogsheads of water, 10 feet high, in an hour.—The most disadvantageous way of employing the power of a horse is to make him carry a load up an inclined plane, for it was observed by De la Hire, that *three* men, with 100 pounds each, will go faster up the inclined plane than a horse with 300 pounds. When the horse walks on a good road, and is loaded with about two hundred weight, he may easily travel 25 miles in the space of seven or eight hours.

425. When a horse is employed in raising coals by means of a wheel and axle, and moves at the rate of about two miles an hour, Mr Fenwick found that he could continue at work 12 hours each day, two and a half of which were spent in short intervals of rest, when he raised a load of 1000 pounds avoirdupois, with a velocity of 13 feet per minute;—and that he will exert a force of 75 pounds for nine hours and a half, when moving with the same velocity. Mr Fenwick also found that 230 ale gallons of water delivered every minute on an overshot water-wheel, 10 feet in diameter; that a common steam-engine, with a cylinder eight inches in diameter, and an improved engine with a cylinder 6.12 inches in diameter, will do the work of one horse, that is, will raise a weight of 1000 pounds avoirdupois, through the height of 13 feet in a minute. It appears from Mr Smeaton's experiments, that Dutch sails in their common position with a radius of 9 feet and a half, —that Dutch sails in their best position with a radius of eight feet, and that his enlarged sails with a radius of seven feet, perform the same work as one man; or perform

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form one-fifth part of the work of a horse. Upon these facts we have constructed the following table, the four first columns of which are taken from Mr Fenwick's Essays on Practical Mechanics.

Table shewing the relative strength of Overshot Wheels, Steam Engines, Horses, Men, and Wind-mills of different kinds.

Number of ale gallons delivered on an overshot wheel, 10 feet in diameter, every minute.	Diameter of the cylinder in the common steam-engine, in inches.	Diameter of the cylinder of the improved steam-engine, in inches.	Number of horses working 12 hours per day, and moving at the rate of two miles per hour.	Number of men working 12 hours a-day.	Radius of Dutch sails in their common position in feet.	Radius of Dutch sails in their best position, in feet.	Radius of Mr Smeaton's enlarged sails, in feet.	Height to which these different powers will raise 1000 pounds avoirdupois in a minute.
230	8.	6.12	1	5	21.24	17.89	15.65	13
390	9.5	7.8	2	10	30.04	25.30	22.13	26
528	10.5	8.2	3	15	36.80	30.98	27.11	39
660	11.5	8.8	4	20	42.48	35.78	31.30	52
790	12.5	9.35	5	25	47.50	40.00	35.00	65
970	14.	10.55	6	30	52.03	43.82	38.34	78
1170	15.4	11.75	7	35	56.90	47.33	41.41	90
1350	16.8	12.8	8	40	60.09	50.60	44.27	104
1445	17.3	13.6	9	45	63.73	53.66	46.96	117
1584	18.5	14.2	10	50	67.17	56.57	49.50	130
1740	19.4	14.8	11	55	70.46	59.33	51.91	143
1900	20.2	15.2	12	60	73.59	61.97	54.22	156
2100	21.	16.2	13	65	76.59	64.5	56.43	169
2300	22.	17.	14	70	79.49	66.94	58.57	182
2500	23.1	17.8	15	75	82.27	69.28	60.62	195
2686	23.9	18.3	16	80	84.97	71.55	62.61	208
2870	24.7	19.	17	85	87.07	73.32	64.16	221
3055	25.5	19.6	18	90	90.13	75.90	67.41	234
3240	26.25	20.1	19	95	92.60	77.98	68.23	247
3420	27.	20.7	20	100	95.00	80.00	70.00	260
3750	28.5	22.2	22	110	99.64	83.90	73.42	286
4000	29.8	23.	24	120	104.06	87.63	76.68	312
4460	31.1	23.9	26	130	108.32	91.22	79.81	338
4850	32.4	24.7	28	140	112.20	94.66	82.82	364
5250	33.6	25.5	30	150	116.35	97.98	85.73	390

426. Dutch sails are always constructed so that the angle of weather may diminish from the centre to the extremity of the sail. They are concave to the wind, and are in their *common position* when their extremities are parallel to the plane in which they move, or perpendicular to the direction of the wind. Dutch sails are in their *best position* when their extremities make an angle of seven degrees with the plane of their motion. Mr Smeaton's enlarged sails are Dutch sails in their best position, but enlarged at their extremities.

427. It appears from M. Coulomb's experiments on Dutch wind-mills, with rectangular sails, that when the distance between the extremities of two opposite sails is 66 feet French, and the breadth of each sail six feet, a wind moving at the rate of 20 feet per second will produce an effect equivalent to 1000 pounds raised through the space of 218 feet in a minute.

According to Watt and Boulton, one of their steam engines, with a cylinder 31 inches in diameter, and which makes 17 double strokes per minute, is equivalent to 40 horses working day and night; that is, to 101 horses working nine hours and a half, the time of constant exertion in the preceding table. When the cylinder is 19 inches in diameter, and the engine makes 25 strokes of four feet each per minute, its power is equivalent to twelve horses working constantly, or thirty horses working nine hours and a half;—and when the cylinder is 24 inches in diameter, and the engine makes 22 strokes, of five feet each, in a minute, its power is equal to that of 20 horses working constantly, or 50 horses working nine hours and a half.

Chap. VII. *On the Construction of Wind-mills.*

428. A wind-mill is represented in fig. 1. where MN is the circular building that contains the machinery, E the extremity of the windshaft, or principal axis, which is generally inclined from 8 to 15 degrees to the horizon; and EA, EB, EC, ED four rectangular frames upon which sails of cloth of the same form are stretched. At the lower extremity G of the sails their surface is inclined to the axis 72°; and at their farthest extremities A, D, &c. the inclination of the sail is about 83°. Now, when the sails are adjusted to the wind, which happens when the wind blows in the direction of the windshaft E, the impulse of the wind upon

Plate CCCXXV. fig. 1.

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upon the oblique sails may be resolved into two forces, one of which acts at right angles to the windshaft, and is therefore employed solely in giving a motion of rotation to the sails and the axis upon which they are fixed. When the mill is used for grinding corn, a crown wheel, fixed to the principal axis E, gives motion to a lantern or trundle, whose axis carries the moveable millstone.

Methods of turning the sails to the wind.

429. That the wind may act with the greatest efficacy upon the sails, the windshaft must have the same direction as the wind. But as this direction is perpetually changing, some apparatus is necessary for bringing the windshaft and sails into their proper position. This is sometimes effected by supporting the machinery on a strong vertical axis, whose pivot moves in a brass socket firmly fixed into the ground, so that the whole machine, by means of a lever, may be made to revolve upon this axis, and be properly adjusted to the direction of the wind. Most wind-mills, however, are furnished with a moveable roof which revolves upon friction rollers inserted in the fixed kerb of the mill; and the adjustment is effected by the assistance of a simple lever. As both these methods of adjustment reqnire the assistance of men, it would be very desireable that the same effect should be produced solely by the action of the wind. This may be done by fixing a large wooden vane or weather-cock at the extremity of a long horizontal arm which lies in the same vertical plane with the windshaft. By this means when the surface of the vane, and its distance from the centre of motion, are sufficiently great, a very gentle breeze will exert a sufficient force upon the vane to turn the machinery, and will always bring the sails and windshaft to their proper position. This weather-cock, it is evident, may be applied either to machines which have a moveable roof, or which revolve upon a vertical arbor.

On the Form and Position of Wind-mill Sails.

The inclination assigned by Parent, erroneous.

430. It appears from the investigations of Parent, that a maximum effect will be produced when the sails are inclined $54\frac{2}{7}$ degrees to the axis of rotation, or when the angle of weather is $35\frac{1}{7}$ (G) degrees. In obtaining this conclusion, however, M. Parent has assumed data which are inadmissible, and has neglected several circumstances which must materially affect the result of his investigations. The angle of inclination assigned by Parent is certainly the most efficacious for giving motion to the sails from a state of rest, and for preventing them from stopping when in motion; but he has not considered that the action of the wind upon a sail at rest is different from its action upon a sail in motion; for since the extremities of the sails move with greater rapidity than the parts nearer the centre, the angle of weather should be greater towards the centre than at the extremity, and should vary with the velocity of each part of the sail. The reason of this is very obvious. It has been demonstrated by Bossut, and established by experience, that when any fluid acts upon a plain surface, the force of impulsion is always exerted most advantageously when the impelled surface is in a state of rest, and that this force diminishes as the velocity of the surface increases. Now, let us suppose with Parent, that the most advantageous angle of weather for the sails of wind-mills is $35\frac{1}{7}$ degrees for that part of the sail which is nearest the centre of rotation, and that the sail has every where this angle of weather; then, since the extremity of the sail moves with the greatest velocity, it will in a manner withdraw itself from the action of the wind, or, to speak more properly, it will not receive the impulse of the wind so advantageously as those parts of the sail which have a less degree of velocity. In order therefore to counteract this diminution of force, we must make the wind act more perpendicularly upon the sail, by diminishing its obliquity or its angle of weather. But since the velocity of every part of the sail is proportional to its distance from the centre of motion, every elementary portion of it must have a different angle of weather diminishing from the centre to the extremity of the sail. The law or rate of diminution, however, is still to be discovered, and we are fortunately in possession of a theorem of Euler's, afterwards given by Maclaurin, which determines this law of variation. Let a represent the velocity of the wind, and c the velocity of any given part of the sail; then the effort of the wind upon that part of the sail will be greatest when the tangent of the angle of the wind's incidence, or of the sail's inclination to the axis, is to radius, as $\sqrt{2+\frac{9cc}{4aa}}+\frac{3c}{2a}$ to 1.

Euler's theorem.

Fig. 2. Explanation and application of this theorem.

431. In order to apply this theorem, let us suppose that the radius or whip ED of the sail $\alpha\beta\delta\gamma$, is divided into six equal parts; that the point n is equidistant from E and D, and is the point of the sail which has the same velocity as the wind; then, in the preceding theorem, we shall have $c=a$, when the sail is loaded to a maximum; and therefore the tangent of the angle, which the surface of the sail at n makes with the axis, when $a=1$, will be $\sqrt{2+\frac{9}{4}}+\frac{3}{2}=3.561=$ tangent of 74° 19′, which gives 15° 41′ for the angle of weather at the point n. Since, at $\frac{3}{6}$ of the radius $c=a$, and since c is proportional to the distance of the corresponding part of the sail from the centre, we will have, at $\frac{1}{6}$ of the radius $s\,m$, $c=\frac{a}{3}$, at $\frac{2}{6}$ of the radius, $c=\frac{2a}{3}$; at $\frac{4}{6}$, $c=\frac{4a}{3}$, at $\frac{5}{6}$, $c=\frac{5a}{3}$; and at the extremity of the radius, $c=2a$. By substituting these different values of c, instead of c in the theorem, and by making $a=1$, the following table will be obtained, which exhibits the angles of inclination and weather which must be given to different parts of the sails.

Parts

(G) The *weather* of the sails is the angle which the surface forms with the plane in which they move, and is equal to the complement of the angle which that surface forms with the axis.

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Parts of the radius from the centre of motion at E.	Velocity of the sail at these distances...or values of c.	Angle made with the axis.		Angle of weather.	
		Deg.	Min	Deg.	Min.
$\frac{1}{6}$	$\frac{a}{3}$	63	26	26	34
$\frac{2}{6}$	$\frac{2a}{3}$	69	54	20	6
$\frac{3}{6}$ or $\frac{1}{2}$	a	74	19	15	4
$\frac{4}{6}$ or $\frac{2}{3}$	$\frac{4a}{3}$	77	20	12	40
$\frac{5}{6}$	$\frac{5a}{3}$	79	27	10	33
1	$2a$	81	0	9	0

Results of Smeaton's experiments.

432. Mr Smeaton found, from a variety of experiments, that the common practice of inclining plane sails from 72° to 75° to the axis, was much more efficacious than the angle assigned by Parent, the effect being as 45 to 31. When the sails were weathered in the Dutch manner, that is, when their surfaces were concave to the wind, and when the angle of inclination increased towards their extremities, they produced a greater effect than when they were weathered either in the common way, or according to Euler's theorem. But when the sails were enlarged at their extremities, as represented at $\alpha\beta$, in fig. 2. so that $\alpha\beta$ was one-third of the radius ED, and α D to D β as 5 to 3, their power was greatest of all, though the surface acted upon by the wind remained the same. If the sails be farther enlarged, the effect is not increased in proportion to the surface; and besides, when the quantity of cloth is great, the machine is much exposed to injury by sudden squalls of wind. In Mr Smeaton's experiments, the angle of weather varied with the distance from the axis; and it appeared from several trials, that the most efficacious angles were those in the following table.

Parts of the radius EA, which is divided into 6 parts	Angle with the axis.	Angle of weather.
1	72	18
2	71	19
3	72	18 middle
4	74	16
5	$77\frac{1}{2}$	$12\frac{1}{2}$
6	83	7

If the radius ED of the sail be 30 feet, then the sail will commence at $\frac{1}{6}$ ED, or 5 feet from the axis, where the angle of inclination will be 72°. At $\frac{2}{6}$ ED, or 10 feet from the axis, the angle will be 71°, and so on.

On the Effect of Wind-mill Sails.

433. The following maxims deduced by Mr Smeaton from his experiments, contain the most accurate information upon this subject.

Effects of wind-mill sails, according to Smeaton.

Maxim 1. The velocity of wind-mill sails, whether unloaded or loaded, so as to produce a maximum effect is nearly as the velocity of the wind, their shape and position being the same.

Maxim 2. The load at the maximum is nearly, but somewhat less than, as the square of the velocity of the wind, the shape and position of the sails being the same.

Maxim 3. The effects of the same sails at a maximum, are nearly, but somewhat less than, as the cubes of the velocity of the wind.

Maxim 4. The load of the same sails at the maximum is nearly as the squares, and their effects as the cubes of their number of turns in a given time.

Maxim 5. When sails are loaded, so as to produce a maximum at a given velocity, and the velocity of the wind increases, the load continuing the same: 1st, The increase of effect, when the increase of the velocity of the wind is small, will be nearly as the squares of those velocities: 2dly, When the velocity of the wind is double, the effects will be nearly as 10 : $27\frac{1}{2}$: But, 3dly, When the velocities compared are more than double of that where the given load produces a maximum, the effects increase nearly in the simple ratio of the velocity of the wind.

Maxim 6. In sails where the figure and positions are similar, and the velocity of the wind the same, the number of turns in a given time will be reciprocally as the radius or length of the sail.

Maxim 7. The load at a maximum that sails of a similar figure and position will overcome at a given distance from the centre of motion, will be as the cube of the radius.

Maxim 8. The effects of sails of similar figure and position are as the square of the radius.

Maxim 9. The velocity of the extremities of Dutch sails, as well as of the enlarged sails, in all their usual positions when unloaded, or even loaded to a maximum, are considerably quicker than the velocity of the wind.

434. A new mode of constructing the sails of wind-mills has been recently given by Mr Sutton, and fully described by Mr Hesleden of Barton, in a work exclusively devoted to the subject.

The limits of this article will not permit us to enter into any discussion respecting the principles upon which Mr Sutton's gravitated sails are constructed; but the subject shall be resumed under the article WINDMILL. It may be proper however to remark that Mr Sutton gives his sails the form represented in fig. 4. and makes the angle of weather at the point M, equidistant from A and B, equal to 22° 30′. The inclination of the sail at any other point N of the sail, is an angle whose sine is the distance of that point from the centre of motion A, the radius being the breadth of the sail at that point. Fig. 3. shews the angles at the different points of the sail; and the apparent and absolute breadth of the sail at these points. Mr Sutton's mode of regulating the velocity of the sails, and of bringing them to a state of rest is particularly ingenious. Fig. 3.

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On Horizontal Wind-mills.

Horizontal wind-mills.

435. Various opinions have been entertained respecting the relative advantages of horizontal and vertical wind-mills. Mr Smeaton, with great justice, gives a decided preference to the latter; but when he asserts that horizontal wind-mills have only $\frac{1}{8}$ or $\frac{1}{10}$ of the power of vertical ones, he certainly forms too low an estimate of their power. Mr Beatson, on the contrary, who has received a patent for the construction of a new horizontal wind-mill, seems to be prejudiced in their favour, and greatly exaggerates their comparative value. From an impartial investigation, it will probably appear, that the truth lies between these two opposite opinions; but before entering on this discussion, we must first consider the nature and form of horizontal winds-mills.

Fig. 4.

436. In fig. 4. CK is the windshaft, which moves upon pivots. Four cross bars, CA, CD, IB, FG, are fixed to this arbor, which carry the frames APIB, DEFG. The sails AI, EG, are stretched upon these frames, and are carried round the axis CK, by the perpendicular impulse of the wind. Upon the axis CK, a toothed wheel is fixed, which gives motion to the particular machinery that is employed. In the figure, only two sails are represented; but there are always other two placed at right angles to these. Now, let the sails be exposed to the wind, and it will be evident that no motion will ensue; for the force of the wind upon the sail AI, is counteracted by an equal and opposite force upon the sail EG. In order then, that the wind may communicate motion to the machine, the force upon the returning sail EG must either be removed by screening it from the wind, or diminished by making it present a less surface when returning against the wind. The first of these methods is adopted in Tartary, and in some provinces of Spain; but is objected to by Mr Beatson, from the inconvenience and expence of the machinery and attendance requisite for turning the screens into their proper positions. Notwithtsanding this objection, however, I am disposed to think that this is the best method of diminishing the action of the wind upon the returning sails, for the moveable screen may easily be made to follow the direction of the wind, and assume its proper position, by means of a large wooden weathercock, without the aid either of men or machinery. It is true, indeed, that the resistance of the air in the returning sails is not completely removed; but it is at least as much diminished as it can be by any method hitherto proposed. Besides, when this plan is resorted to, there is no occasion for any moveable flaps and hinges, which must add greatly to the expence of every other method.

Common method of bringing back the sails against the wind.

Beatson's method.

437. The mode of bringing the sails back against the wind, which Mr Beatson invented, is perhaps, the simplest and best of the kind. He makes each sail AI to consist of six or eight flaps or vanes, AP *b* 1, *b* 1 *c* 2, &c. moving upon hinges represented by the dark lines, AP, *b* 1, *c* 2, &c. so that the lower side *b* 1, of the first flap overlaps the hinge or higher side of the second flap, and so on. When the wind, therefore, acts upon the sail AI, each flap will press upon the hinge of the one immediately below it, and the whole surface of the sail will be exposed to its action. But when the sail AI returns against the wind, the flaps will revolve round upon their hinges, and present only their edges to the wind, as is represented at EG, so that the resistance occasioned by the return of the sail must be greatly diminished, and the motion will be continued by the great superiority of force exerted upon the sails in the position AI. In computing the force of the wind upon the sail AI, and the resistance opposed to it by the edges of the flaps in EG, Mr Beatson finds, that when the pressure upon the former is 1872 pounds, the resistance opposed by the latter is only about 36 pounds, or $\frac{1}{52}$ part of the whole force; but he neglects the action of the wind upon the arms CA, &c. and the frames which carry the sails, because they expose the same surface in the position AI, as in the position EG. This omission, however, has a tendency to mislead us in the present case, as we shall now see, for we ought to compare the whole force exerted upon the arms, as well as the sail, with the whole resistance which these arms and the edges of the flaps oppose to the motion of the windmill. By inspecting fig. 4. it will appear, that if the force upon the edges of the flaps, which Mr Beatson supposed to be 12 in number, amounts to 36 pounds, the force spent upon the bars CD, DG, GF, FE, &c. cannot be less than 60 pounds. Now, since these bars are acted upon with an equal force, when the sails have the position AI, $1872+60=1932$ will be the force exerted upon the sail AI, and its appendages, while the opposite force upon the bars and edges of the flaps when returning against the wind will be $36+60=96$ pounds, which is nearly $\frac{1}{20}$ of 1932, instead of $\frac{1}{52}$ as computed by Mr Beatson. Hence we may see the probable advantages of a screen over moveable flaps, as it will preserve not only the sails, but the arms and the frame which support it, from the action of the wind.

Comparisons between vertical and horizontal wind mills.

438. We shall now conclude this chapter with a comparison of the power of horizontal and vertical wind-mills. It was already stated, that Mr Smeaton rather underrated the former, while he maintained that they have only $\frac{1}{8}$ or $\frac{1}{10}$ the power of the latter. He observes, that when the vanes of a horizontal and a vertical mill are of the same dimensions, the power of the latter is four times that of the former, because, in the first case, only one sail is acted upon at once, while, in the second case, all the four receive the impulse of the wind. This, however, is not strictly true, since the vertical sails are all oblique to the direction of the wind. Let us suppose that the area of each sail is 100 square feet; then the power of the horizontal sail will be 100, and the power of a vertical sail may be called $100 \times \overline{\text{sine } 70^{\circ}}^{2}$ (70° being the common angle of inclination) $=88$ nearly; but since there are four vertical sails, the power of them all will be $4 \times 88=352$; so that the power of the horizontal sail is to that of the four vertical ones as 1 to 3.52, and not as 1 to 4, according to Mr Smeaton. But Mr Smeaton also observes, that if we consider the farther disadvantage which arises from the difficulty of getting the sails back against the wind, we need not wonder if horizontal wind-mills have only about $\frac{1}{8}$ or $\frac{1}{10}$ the power of the common sort. We have already seen, that the resistance occasioned by the return of the sails amounts to $\frac{1}{20}$ of the whole force which they receive; by subtracting $\frac{1}{20}$, therefore, from $\frac{1}{3.52}$, we shall find that the

ractical Mechanics. the power of horizontal wind-mills is only $\frac{1.03}{4.40}$, or little more than $\frac{1}{4}$ that of vertical ones. This calculation proceeds upon a supposition, that the whole force exerted upon vertical sails is employed in turning them round the axis of motion; whereas a considerable part of this force is lost in pressing the pivot of the axis or windshaft against its gudgeon. Mr Smeaton has overlooked this circumstance, otherwise he could never have maintained that the power of four vertical sails was quadruple the power of one horizontal sail, the dimensions of each being the same. Taking this circumstance into the account, we cannot be far wrong in saying, that in theory at least, if not in practice, the power of a horizontal wind-mill is about $\frac{1}{8}$ or $\frac{1}{4}$ of the power of a vertical one, when the quantity of surface and the form of the sails is the same, and when every part of the horizontal sails has the same distance from the axis of motion as the corresponding parts of the vertical sails. But if the horizontal sails have the position AI, EG, in fig. 4. instead of the position CA $d\,m$, CD $o\,n$, their power will be greatly increased, though the quantity of surface is the same, because the part CP $3\,m$ being transferred to BI $3\,d$, has much more power to turn the sails.

Chap. VIII. *On the Construction of Wheel Carriages.*

the size carriage eels. Plate CCXXV. Fig. 6. 439. It is evident from Art. 60. that when a wheel surmounts an obstacle, it acts as a lever of the first kind, and that its power to overcome such resistances increases with its diameter. The power of the force P, for example, to raise the wheel NB over the eminence C, is proportional to the vertical lever FC, which increases with the diameter of the wheel, while the lever of resistance FA, by which the weight of the wheel acts, remains unchanged; hence we see the advantages of large wheels for overcoming such obstacles as generally resist the motion of wheel carriages. There are some circumstances, however, which, independent of the additional weight and expence of large wheels, prescribe limits to their size. If the radius AC of the wheel exceeds the height of that part of the horse to which the traces are attached, the line of traction DA will be oblique to the horizon, and part of the power P will be employed in pressing the wheel upon the ground. A wheel exceeding four and a half feet radius, which is the general distance from the ground of that part of the horse to which the traces are attached, has still the advantage of a smaller wheel; but when we consider that the traces or poles of the cart will, in this case, rub against the flanks of the horses, so that the power of the wheel is diminished by the increase of its weight, we shall be convinced that no power is gained by making the radius of the wheels greater than four and a half feet. Even this size is too great, as shall be afterwards shown, when we treat of the line of traction, so that we may safely assert, that the diameter of wheels should never be greater than six feet. The fore wheels of our carriages are still unaccountably small, and it is not uncommon to see carts moving upon wheels scarcely 14 inches in diameter. The convenience of turning is urged as the reason for diminishing the fore wheels of carriages, and the facility of loading the cart is considered as a sufficient reason for using wheels so small as 14 inches. The first of these advantages, however, may be obtained by going to the end of a street, or to a proper place for turning the carriage; and a few additional turns of a windlass will be sufficient to convey the heaviest loads into carts mounted on high wheels.

440. The next thing to be determined is the shape of the wheels. Now it is certainly a matter of surprise how the unnatural shape which is at present given to them could ever have been brought into use. A cylindrical wheel, with the spokes perpendicular to the naves, is undoubtedly the form which every mechanic would give to his wheels, before he had heard of the pretended advantages of concave or dishing wheels, or those which have inclined spokes and conical rims. It has been alleged, indeed, that the form represented in fig. 5. when A r, B s is the conical rim, and o A, p B the inclined spokes, renders the wheel stronger than it would otherwise be; that by extending the base of the carriage it prevents it from being overturned; that it hinders the fellies from rubbing against the load or the sides of the cart; and that when one wheel falls into a rut, and therefore supports more than one half of the load, the spokes are brought into a vertical position, which renders them more capable of sustaining the additional weight. Now it is evident that the second of these advantages is very trifling, and may be obtained, when required, by interposing a piece of board between the wheel and the load. Plate CCCXXV. Fig. 5.

441. The other two advantages exist only in very bad roads; and if they are necessary, which we much question, in a country like this, where the roads are so excellently made, and so regularly repaired, they can easily be procured, by making the axle-tree a few inches longer, and increasing the strength of the spokes. But it is allowed on all hands that perpendicular spokes are preferable on level ground. The inclination of the spokes, therefore, which renders concave wheels advantageous in rugged and unequal roads, renders them disadvantageous when the roads are in good order; and where the good roads are more numerous than the bad ones, as they certainly are in this country, the disadvantages of concave wheels must overbalance their advantages. It is true indeed that in concave wheels, the spokes are in their strongest position, when they are exposed to the severest strains, that is, when one wheel is in a deep rut, and sustains more than one half of the load: but it is equally true that on level ground, where the spokes are in their weakest position, a less severe strain, by continuing for a much longer time, may be equally if not more detrimental to the wheel.

Upon these observations we might rest the opinion which we have been maintaining, and appeal for its truth to the judgment of every intelligent and unbiassed mind; but we shall go a step farther, and endeavour to show that concave dishing wheels are more expensive, more injurious to the roads, more liable to be broken by accidents, and less durable in general, than those wheels in which the spokes are perpendicular to the naves. By inspecting fig. 5. it will appear that the whole of the pressure which the wheel AB sustains is exerted along the inclined spoke $p\,s$, and therefore acts obliquely upon the level ground n D, whether the rims are conical or cylindrical. This oblique action must necessarily

necessarily injure the roads, by loosening the stones more between B and D than between B and n, and if the load were sufficiently great, the stones would start up between s and D. The texture of the roads, indeed, is sufficiently firm to prevent this from taking place; but in consequence of the oblique pressure, the stones between s and D will at least be loosened, and by admitting the rain the whole of the road will be materially damaged. But when the spokes are perpendicular to the nave as pn, and when the rims mA, nB are cylindrical, or parallel to the ground, the weight sustained by the wheel will act perpendicularly upon the road; and however much that weight is increased, its action can have no tendency to derange the materials of which it is composed, but is rather calculated to consolidate them, and render the road more firm and durable.

442. It was observed that concave wheels are more expensive than plane ones. This additional expence arises from the greater quantity of wood and workmanship which the former require; for in order that dishing wheels may be of the same perpendicular height as plane ones, the spokes of the former must exceed in length those of the latter, as much as the hypothenuse oA of the triangle oAn exceeds the side om; and therefore the weight and the resistance of such wheels must be proportionably great. The inclined spokes, too, cannot be formed nor inserted with such facility as perpendicular ones. The extremity of the spoke which is fixed into the nave is inserted at right angles to it, in the direction $o\ p$, and if the rims are cylindrical, the other spoke should be inserted in a similar manner; while the intermediate portion has an inclined position. There are therefore two flexures or bendings in the spokes of concave wheels, which requires them to be formed out of a larger piece of wood than if they had no such flexures, and renders them liable to be broken by any sudden strain at the points of flexure.

443. We shall now dismiss the subject of concave wheels with one observation more, and we beg the reader's attention to it, because it appears to be decisive of the question. The obstacles which carriages have to encounter, are almost never spherical protuberances that permit the elevated wheel to resume by degrees its horizontal position. They are generally of such a nature, that the wheel is instantaneously precipitated from their top to the level ground. Now the momentum with which the wheel strikes the ground is very great, arising from a successive accumulation of force. The velocity of the elevated wheel is considerable when it reaches the top of the eminence, and while it is tumbling into the level ground, it is receiving gradually that proportion of the load which was transferred to the other wheel, till having recovered the whole, it impinges against the ground with great velocity and force. But in concave wheels the spoke which then strikes the ground is in its weakest position, and therefore much more liable to be broken by the impetus of the fall, than the spokes of the lowest wheel by the mere transference of additional weight. Whereas, if the spokes be perpendicular to the nave, they receive this sudden shock in their strongest position, and are in no danger of giving way to the strain.

444. In the preceding observations we have supposed the rims of the wheels to be cylindrical. In concave wheels, however, the rims are uniformly made of a conical form, as A r, B s, fig. 5. which not only increases the disadvantages which we have ascribed to them, but adds many more to the number. Mr Cumming, in a late Treatise on Wheel Carriages, solely devoted to the consideration of this single point, has shewn with great ability the disadvantages of conical rims, and the propriety of making them cylindrical; but we are of opinion that he has ascribed to conical rims several disadvantages which arise chiefly from an inclination of the spokes. He insists much upon the injury done to the roads by the use of conical rims; yet though we are convinced that they are more injurious to pavements and highways than cylindrical rims, we are equally convinced, that this injury is occasioned chiefly by the oblique pressure of the inclined spokes. The defects of conical rims are so numerous and palpable, that it is wonderful they should have been so long overlooked. Every cone that is put in motion upon a plane surface will revolve round its vertex, and if force is employed to confine it to a straight line, the smaller parts of the cone will be dragged along the ground and the friction greatly increased. Now when a carriage moves upon conical wheels, one part of the cone rolls while the other is dragged along, and though confined to a rectilineal direction by external force, their natural tendency to revolve round their vertex occasions a great and continued friction upon the linch pin, the shoulder of the axle-tree, and the sides of deep ruts.

445. The shape of the wheels being thus determined, we must now attend to some particular parts of their construction. The iron plates of which the rims are composed should never be less than three inches in breadth, as narrow rims sink deep into the ground, and therefore injure the roads and fatigue the horses. Mr Walker, indeed, attempts to threw ridicule upon the act of parliament which enjoined the use of broad wheels; but he does not assign any sufficient reason for his opinion, and ought to have known that several excellent and well devised experiments were lately instituted by Boulard and Margueron, which evince in the most satisfactory manner, the great utility of broad wheels. Upon this subject an observation occurs to us, which has not been generally attended to, and which appears to remove all the objections which can be urged against broad rims. When any load is supported upon two points, each point supports one half of the weight; if the points are increased to four, each will sustain one-fourth of the load, and so on; the pressure upon each point of support diminishing as the number of points increases. If a weight therefore is supported by a broad surface, the points of support are infinite in number, and each of them will bear an infinitely small portion of the load; and, in the same way, every finite portion of this surface will sustain a part of the weight inversely proportional to the number of similar portions which the surface contains. Let us now suppose that a cart carrying a load of sixteen hundred weight is supported upon wheels whose rims are four inches in breadth, and that one of the wheels passes over four stones, each of them an inch broad and equally high, and capable of being pulverized only by a pressure of four hundred pounds weight. Then as each wheel sustains one half of the load, and as the wheel which passes

over

over the stones has four points of support, each stone will bear a weight of two hundred weight, and therefore will not be broken. But if the same cart, with rims only two inches in breadth, should pass the same way, it will cover only two of the stones; and the wheel having now only two points of support, each stone will be pressed with a weight of four hundred weight, and will therefore be reduced to powder. Hence we may infer that narrow wheels are in another point of view injurious to the roads, by pulverizing the materials of which they are composed.

446. As the rims of wheels wear soonest at their edges they should be made thinner in the middle, and ought to be fastened to the fellies with nails of such a kind that their heads may not rise above the surface of the rims. In some military waggons we have seen the heads of these nails rising an inch above the rims, which not only destroys the pavement of streets, but opposes a continual resistance to the motion of the wheel. If these nails were eight in number, the wheel would experience the same resistance, as if it had to surmount eight obstacles, one inch high, during every revolution. The fellies on which the rims are fixed should in carriages be three inches and a fourth deep, and in waggons four inches. The naves should be thickest at the place where the spokes are inserted; and the holes in which the spokes are placed should not be bored quite through, as the grease upon the axle-tree would insinuate itself between the spoke and the naves, and prevent that close adhesion which is necessary to the strength of the wheel.

On the Position of the Wheels.

447. It must naturally occur to every person reflecting upon this subject, that the axle-trees should be straight and the wheels perfectly parallel, so that they may not be wider at their highest than at their lowest point, whether they are of a conical or a cylindrical form. In this country, however, the wheels are always made concave, and the ends of the axle-trees are universally bent downwards, in order to make them spread at the top and approach nearer below. In some carriages which we have examined, where the wheels were only four feet six inches in diameter, the distance of the wheels at top was fully six feet, and their distance below only four feet eight inches. By this foolish practice the very advantages which may be derived from the concavity of the wheels are completely taken away, while many of the disadvantages remain; more room is taken up in the coach-house, and the carriage is more liable to be overturned by the contraction of its base.

448. With some mechanics it is a practice to bend the ends of the axle-trees forwards, and thus make the wheels wider behind than before. This blunder has been strenuously defended by Mr Henry Beighton, who maintains that wheels in this position are more favourable for turning, since, when the wheels are parallel, the outermost when turning would press against the linch pin, and the innermost would rest against the shoulder of the axle-tree. In rectilineal motions, however, these converging wheels engender a great deal of friction both on the axle and the ground, and must therefore be more disadvantageous than parallel ones.

On the Line of Traction, and the Method by which Horses exert their strength.

449. M. Camus attempted to shew that the line of traction should always be parallel to the ground on which the carriage is moving, both because the horse can exert his greatest strength in this direction, and because the line of draught being perpendicular to the vertical spoke of the wheel, acts with the largest possible lever. M. Couplet, however, considering that the roads are never perfectly level, and that the wheels are constantly surmounting small eminences even in the best of roads, recommends the line of traction to be oblique to the horizon. By this means the line of draught HA, (which is by far too much inclined in the figure) will in general be perpendicular to the lever AC which mounts the eminence, and will therefore act with the longest lever when there is the greatest necessity for it. We ought to consider also, that when a horse pulls hard against any load, he always brings his breast nearer the ground, and therefore it follows, that if a horizontal line of traction be preferable to all others, the direction of the traces should be inclined to the horizon when the horse is at rest, in order that it may be horizontal when he lowers his breast and exerts his utmost force. The particular manner, however, in which living agents exert their strength against great loads, seems to have been unknown both to Camus and Couplet, and to many succeeding writers upon this subject. It is to M. Deparcieux, an excellent philosopher and ingenious mechanic, that we are indebted for the only accurate information with which we are furnished; and we are sorry to see that philosophers who flourished after him have overlooked his important instructions. In his memoir on the draught of horses he has shewn in the most satisfactory manner, that animals draw by their weight, and not by the force of their muscles. In four-footed animals, the hinder feet is the fulcrum of the lever by which their weight acts against the load, and when the animal pulls hard, it depresses its chest and thus increases the lever of its weight, and diminishes the lever by which the load resists its efforts. Thus, in fig. 6. let P be the load, AD the line of traction, and let us suppose FC to be the hinder leg of the horse, and AE part of its body, A its chest or centre of gravity, and CE the level road. Then AFC will represent the crooked lever by which the horse acts, which is equivalent to the straight one AC. But when the horse's weight acts downwards at A, so as to drag forward the rope AD and raise the load P, CE will represent the power of the lever in this position, or the lever of the horse's weight, and CF the lever by which it is resisted by the load, or the lever of resistance. Now if the horse lowers its centre of gravity A, which it always does when it pulls hard, it is evident that CE, the lever of its weight, will be increased, while CF the lever of its resistance will be diminished, for the line of traction AD will approach nearer to CE. Hence we see the great benefit which may be derived from large horses; for the lever AC necessarily increases with their size, and their power is always proportioned to the length of this lever, their weight remaining the same. Large horses, therefore, and other animals, will draw more than small ones, even though they have less muscular force,

Fig. 6.

force, and are unable to carry such a heavy burden. The force of the muscles tends only to make the horse carry continually forward his centre of gravity, or, in other words, the weight of the animal produces the draught, and the play and force of its muscles serve to continue it.

450. From these remarks, then, we may deduce the proper position of the line of traction. When the line of traction is horizontal, as AD, the lever of resistance is CF; but if this line is oblique to the horizon, as A d, the lever of resistance is diminished to C f, while the lever of the horse's weight always remains the same. Hence it appears, that inclined traces are much more advantageous than horizontal ones, as they uniformly diminish the resistance to be overcome. Deparcieux, however, has investigated experimentally the most favourable angle of inclination, and found, that when the angle DAF made by the trace A d and a horizontal line is fourteen or fifteen degrees, the horses pulled with the greatest facility and force. This value of the angle of draught will require the weight of the spring-tree bar, to which the traces are attached in four-wheeled carriages, to be *one-half* of the height of that part of the horse's breast to which the fore end of the trace is connected.

Fig. 7. 451. When several horses are yoked in the same carriage as represented in fig. 7. and when the declivity changes, the length of the traces has a considerable influence upon the draught. From the point E where the traces are fastened to the horse next the load, draw ER to the same point in the second horse R, and let R′ be another position of the second horse, it is required to find the difference of effect that will be produced by placing the second horse at R or at R′, or the comparative advantages of short and long traces. From R′, the point where the traces are fixed, draw R′F′E; and from E draw E m n parallel to the declivity DA. Take EF=EF′ to represent the power of the horse in the direction of the traces, which will be the same whether he is yoked at R or at R′; draw EA perpendicular to DA, F n, F′ m parallel to EA, and F φ, F′ f parallel to E n. Then since the second horse when at R pulls with a force represented by FE, in the direction FE, we may resolve this force into the two forces, E n, E φ, one of which E n is solely employed in dragging the cart up the inclined plane DA, while the other E φ is solely employed in pressing the first horse E to the ground. Let the horse be now removed from R to R′, the direction of the traces becomes RF′E, and F′E=FE is the power exerted by the horse at R′ and the direction in which it is exerted. But this force is equivalent to the forces E m, E f, the first of which acts directly against the load, while the other presses the horse against the ground. Hence we see the disadvantages of long traces, for the force which draws the load when the horse is at R′ is to the force when the horse is at R, as E m to E n, and the forces which press the horse upon the ground as E f to E φ, or as F′ m to F n. Now $\mathrm{E}\varphi = \mathrm{F}n = \mathrm{FE} \times \sin.\, n\mathrm{EF}$; hence $\mathrm{F}\varphi = \mathrm{FE} \times \sin.\, (\overline{n\mathrm{E}g' - \mathrm{FE}g'})$ (g' E being parallel to AB′) and $\mathrm{E}n = \mathrm{EF} \times \cos.\, (n\mathrm{E}g' - \mathrm{FE}g')$. In like manner we have $\mathrm{E}f = \mathrm{FE} \times \sin.\, (n\mathrm{E}g' - \mathrm{F'E}g')$, and $\mathrm{E}m = \mathrm{EF} \times \cos.\, (n\mathrm{E}g' - \mathrm{F'E}g')$. Now $\sin.\, \mathrm{FE}g' = \sin.\, \mathrm{FE}g = \frac{\mathrm{R}g}{\mathrm{ER}}$, and $\sin.\, \mathrm{FE}g' = \frac{\mathrm{R'}g'}{\mathrm{ER'}} = \frac{\mathrm{R}g}{\mathrm{ER'}}$; but $\mathrm{R}g = \mathrm{R'}g' = \mathrm{BR} - \mathrm{EQ} = \mathrm{BR} - \mathrm{BR} \times \cos.\, n\mathrm{E}g' = \mathrm{BR} \times (1 - \cos.\, n\mathrm{E}g)$. By substituting this value in the equations which contain the values of E φ, E n, E f, E m, and considering that the angles FE g', F′E g' are always so small that their arcs differ very little from their sines, we have $\mathrm{FE}g = \frac{\mathrm{BR} \times \overline{1 - \cos.\, n\mathrm{E}g}}{\mathrm{ER}}$, and

$$\mathrm{F'E}g' = \frac{\mathrm{BR} \times \overline{1 - \cos.\, n\mathrm{E}g}}{\mathrm{ER'}}.$$

By substituting these values in the preceding equations, we have

$$\mathrm{E}\varphi = \mathrm{EF} \times \sin.\, (n\mathrm{E}g - \frac{\mathrm{BR} \times \overline{1 - \cos.\, n\mathrm{E}g}}{\mathrm{ER}},$$

$$\mathrm{E}fn = \mathrm{EF} \times \sin.\, (n\mathrm{E}g - \frac{\mathrm{BR} \times \overline{1 - \cos.\, n\mathrm{E}g}}{\mathrm{ER'}},$$

$$\mathrm{E}n = \mathrm{EF} \times \cos.\, (n\mathrm{E}g - \frac{\mathrm{BR} \times \overline{1 - \cos.\, n\mathrm{E}g}}{\mathrm{ER}},$$

$$\mathrm{E}m = \mathrm{EF} \times \cos.\, (n\mathrm{E}g - \frac{\mathrm{BR} \times \overline{1 - \cos.\, n\mathrm{E}g}}{\mathrm{ER'}}.$$

If AB is horizontal, and the declivity $\mathrm{AD} = \frac{1}{6}$, we shall have $n\mathrm{E}g = 9^\circ\ 28'$, or in parts of the radius=0.16522, and $\cos.\, n\mathrm{E}g = 0.98638$. Then, if EF=200 pounds, BR=$3\frac{1}{2}$ feet, ER=8 feet, ER′=12 feet, then we shall have from the preceding formulæ, E φ=31.716 pounds, E f=32.350 pounds, E n=197.470 pounds, and E m=197.404. Hence an additional length of four feet to traces eight feet long, presses the horse E to the ground with an additional force of 32.250—31.716 =0.534 pounds, and diminishes the effect of the other horse by 0.066 pounds.

On the Position of the Centre of Gravity, and the manner of disposing the load.

452. If the axle-tree of a two-wheeled carriage pass through the centre of gravity of the load, the carriage will be in equilibrio in every position in which it can be placed with respect to the axle-tree; and in going up and down hill the whole load will be sustained by the wheels, and will have no tendency either to press the horse to the ground or to raise him from it. But if the centre of gravity is above the axle-tree, as it must necessarily be, according to the present construction of wheel-carriages, a great part of the load will be thrown on the back of the horses from the wheels when going down a steep road, and thus tend to accelerate the motion of the carriage which the animal is striving to prevent; while, in ascending steep roads, a part of the load will be thrown behind the wheels, and tend to raise the horse from the ground, when there is the greatest necessity for some weight on his back to enable him to fix his feet in the earth, and overcome the great resistance which is occasioned by the steepness of the road. On the contrary, if the centre of gravity is below the axle, the horse will be pressed to the ground in going up hill, and lifted from it when going down. In all these cases, therefore, where the centre of gravity is either on the axle-tree or directly above it or below, the

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the horse will bear no part of the load in level ground. In some situations the animal will be lifted from the ground when there is the greatest necessity for his being pressed to it, and he will sometimes bear a great proportion of the load when he should rather be relieved of it.

453. The only way of remedying these evils, is to assign such a position to the centre of gravity, that the horse may bear some portion of the weight when he must exert great force against the load, that is, in level ground, and when he is ascending steep roads; for no animal can pull with its greatest effort unless it is pressed to the ground.—Now this may be in some measure effected in the following manner. Let BCN be the wheel of a cart, AD one of the shafts, D that part of it where the cart is suspended on the back of the horse, and A the axle-tree; then, if the centre of gravity of the load is placed at m, a point equidistant from the two wheels, but below the line DA, and before the axletree,—the horse will bear a certain weight on level ground,—a greater weight when he is going up hill and has more occasion for it, and less weight when he is going down hill, and does not require to be pressed to the ground: All this will be evident from the figure.—When we recollect that the shaft DA is horizontal, the centre of gravity will press more upon the point of suspension D the nearer it comes to it; or the pressure upon D, or the horse's back, will be proportional to the distance of the centre of gravity from A. If m, therefore, be the centre of gravity, b A will represent its pressure upon D, when the shaft DA is horizontal. When the cart is ascending a steep road, AH will be the position of the shaft, the centre of gravity will be raised to a, and a A will be the pressure upon D. But if the cart is going down hill, AC will be the position of the shaft, the centre of gravity will be depressed to n, and c A will represent the pressure upon the horse's back. The weight sustained by the horse, therefore, is properly regulated by placing the centre of gravity at m. We have still, however, to determine the proper length of $b\,a$ and $b\,m$, the distance of the centre of gravity from the axle, and from the horizontal line DA; but as these depend upon the nature and inclination of the roads, upon the length of the shaft DA, which depends on the size of the horse, on the magnitude of the load, and on other variable circumstances, it would be impossible to fix their value.—If the load, along with the cart, weighs 400 pounds; if the distance DA be eight feet, and if the horse should bear 50 pounds of the weight, then b A should be one foot, which, being one-eighth of DA, will make the pressure upon D exactly 50 pounds. If the road slopes four inches in a foot, $b\,m$ must be four inches, or the angle $b\,\mathrm{A}\,m$ should be equal to the inclination of the road; for then the point m will rise to a when ascending such a road, and will press with its greatest force on the back of the horse.

Plate CCCXXV. Fig. 5.

454. When carts are not made in this manner, we may, in some degree obtain the same end by judiciously disposing the load. Let us suppose that the centre of gravity is at O when the cart is loaded with homogeneous materials, such as sand, lime, &c. then if the load is to consist of heterogeneous substances, or bodies of different weights, we should place the heaviest at the bottom and nearest the front, which will not only lower the point o, but will bring it forward, and nearer the proper position m. Part of the load, too, might be suspended below the fore part of the carriage in dry weather, and the centre of gravity would approach still nearer the point m. When the point m is thus depressed, the weight on the horse is not only judiciously regulated, but the cart would be prevented from overturning; and in rugged roads the weight sustained by each wheel would be in a great degree equalised.

Description of different Carriages.

Carriages that move without horses. Fig. 8.

455. In figure 8. is represented a carriage invented by Mr Richard, a physician in Rochelle, which moves without horses, merely by the exertion of the passengers. The machinery by which this is effected is placed in a box behind the carriage, and is shewn in figure 9. where AA is a small axis fixed into the box, and B a pulley over which a rope passes whose two extremities are tied to the ends of the levers or treddles C, D: the other ends of the levers are fixed by joints to the cross beam MF. The cranks FF are fixed to the axle KL, and move upon it as a centre. Each of them has a detent tooth at F which catches in the teeth of the wheels H, H, so that they can move from F to H without moving the wheel, but the detent tooth catches in the teeth of the wheels when the cranks are brought backward, and therefore bring the wheel along with them. When the foot of the passenger, therefore, is placed upon the treddle D, it brings down the crank F and along with it the wheel H, so that the large wheels fixed on the same axis perform part of a revolution; but when D is depressed, the rope DA descends, the extremity C of the other treddle rises, and the crank F rising along with it, takes into the teeth of the wheel H, so that when the elevated treddle C is depressed, the wheels H, H, and consequently the wheels I, I, perform another part of a revolution. In this way, by continuing to work at the treddles, the machine advances with a regular pace. Fig. 9.

456. A carriage of this kind, where the mechanism is much more simple and beautiful than that which we have described, has been lately invented and constructed by Mr Nasmyth of Edinburgh, a gentleman whose mechanical genius is scarcely inferior to his talents as a painter. The pulley B and axle AA, are rendered unnecessary; leather straps are substituted in place of the cranks F, F, and the whole mechanism is contained in two small cylindrical boxes about six inches in diameter, and one and a half broad.

457. A carriage driven by the action of the wind is exhibited in fig. 10. It is fixed on four wheels, and moved by the impulse of the wind upon the sails C, D, being guided by the rudder E. Carriages of this kind will answer very well in a level country where the roads are good and the wind fair; and are said to be much used in China. In Holland they sometimes use similar vehicles for travelling upon the ice; but they have a sledge instead of wheels, so that if the ice should happen to break, there will be no danger of sinking. Stephinus, a Dutchman, is said to have constructed one of these carriages with wheels, which travelled at the rate of 21 miles an hour with a very strong wind. Fig. 10.

458. The carriage represented in fig. 11. is made so as to sail against the wind by means of the spiral sails Fig. 11.

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E, F, G, H, one of which F, is expanded by the wind. The impulse of the wind upon the sails gives a rotatory motion to the axle M, furnished with a cog-wheel K, whose trundles act upon teeth placed on the inside of the fore-wheels.

Fig. 12.

459. A carriage which cannot be overturned is represented in figure 12. where AB is the body of the carriage, consisting of a hollow globe, made of leather or wood, at the bottom of which is placed an immoveable weight proportioned to the load which the carriage is to bear. Two horizontal circles of iron D, E, connected with bars HI, and two vertical circles F, G, surround the globe; and the wheels are fastened by a handle K to the perpendicular bars HI. Then since the body of the carriage moves freely in every direction within the iron circles, the centre of gravity will always be near C, and the carriage will preserve an upright position even if the wheels and frame were overturned.

PART III. DESCRIPTION OF MACHINES.

Chap. I. *Machines which illustrate the doctrines of Mechanics, or are connected with them.*

1. *Atwood's Machine.*

Atwood's machine, Plate CCCXXVI. Fig. 1. 2. 3. &c.

460. THE ingenious machine invented by Mr Atwood for illustrating the doctrines of accelerated and retarded motion, is represented in figs. 1, 2, 3, 4, 5, 6, and enables us to discover, 1. The quantity of matter moved. 2. The moving force. 3. The space described. 4. The time of description; and, 5. The velocity acquired at the end of that time.

461. 1. *Of the quantity of matter moved.*—In order to observe the effects of the moving force, which is the object of any experiment, the interference of all other forces should be prevented: the quantity of matter moved, therefore, considering it before any impelling force has been applied, should be without weight; for though it be impossible to abstract weight from any substance whatever, yet it may be so counteracted as to produce no sensible effect. Thus in the machine

Fig. 1.

fig. 1. A, B represent two equal weights affixed to the extremities of a very fine silk thread: this thread is stretched over a wheel or fixed pulley *a b c d*, moveable round a horizontal axis: the two weights A, B being equal, and acting against each other, remain in equilibrio; and when the least weight is superadded to either (setting aside the effects of friction), it will preponderate. When A, B are set in motion by the action of any weight m, the sum $A+B+m$, would constitute the whole mass moved, but for the inertia of the materials which must necessarily be used in the communication of motion. These materials consist of, 1. The wheel *a b c d*, over which the thread sustaining A and B passes. 2. The four friction wheels on which the axle of the wheel *a b c d* rests. 3. The thread by which the bodies A and B are connected, so as when set in motion to move with equal velocities. The weight and inertia of the thread are too small to have any sensible effect on the experiments; but the inertia of the other materials constitute a considerable proportion of the mass moved, and must therefore be taken into account. Since when A and B are put in motion, they must move with a velocity equal to that of the circumference of the wheel *a b c d* to which the thread is applied; it follows, that if the whole mass of the wheels were accumulated in this circumference, its inertia would be truly estimated by the quantity of matter moved; but since the parts of the wheels move with different velocities, their effects in resisting the communication of motion to A and B by their inertia will be different; those parts which are furthest from the axis resisting more than those which revolve nearer, in a duplicate proportion of those distances, (see Rotation). If the figures of the wheels were regular, the distances of their centres of gyration from their axes of motion would be given, and consequently an equivalent weight, which being accumulated uniformly in the circumference *a b c d*, would exert an inertia equal to that of the wheels in their constructed form, would also be given. But as the figures are irregular, recourse must be had to experiment, to assign that quantity of matter, which being accumulated uniformly in the circumference of the wheel *a b c d*, would resist the communication of motion to A in the same manner as the wheels.

In order to ascertain the inertia of the wheel *a b c d*, with that of the friction wheels, the weights AB being removed, the following experiment was made.

A weight of 30 grains was affixed to a silk thread of inconsiderable weight; this thread being wound round the wheel *a b c d*, the weight 30 grains by descending from rest communicated motion to the wheel, and by many trials was observed to describe a space of about $38\frac{1}{2}$ inches in 3 seconds. From these data the equivalent mass or inertia of the wheels will be known from this rule.

Fig. 2.

Let a weight P, fig. 2. be applied to communicate motion to a system of bodies by means of a very slender and flexible thread going round the wheel SLDIM, through the centre of which the axis passes (G being the common centre of gravity, R the centre of gravity of the matter contained in this line, and O the centre of oscillation). Let this weight descend from rest through any convenient space s inches, and let the observed time of its descent be t seconds; then if l be the space through which bodies descend freely by gravity in one second, the equivalent weight sought $=$

$$\frac{W \times SR \times SO}{SD^2} = \frac{P \times t^2 l}{s} - P.$$

Here we have $p=30$ grains, $t=3$ seconds, $l=193$ inches, $s=38.5$ inches; and $\frac{P \times t^2 l}{s} - P = \frac{30 \times 9 \times 193}{385}$ $30 = 1323$ grains, or $2\frac{3}{4}$ ounces.

This is the inertia equivalent to that of the wheel *a b c d*, and the friction wheels together: for the rule extends to the estimation of the inertia of the mass contained in all the wheels.

Fig.

The resistance to motion therefore arising from the wheel's inertia, will be the same as if they were absolutely

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lutely removed, and a mass of $2\frac{1}{4}$ ounces uniformly accumulated in the circumference of the wheel *a b c d*. This being premised, let the boxes A and B be replaced, being suspended by the silk thread over the wheel or pulley *a b c d*, and balancing each other: suppose that any weight m be added to A so that it shall descend, the exact quantity of matter moved, during the descent of the weight A, will be ascertained, for the whole mass will be $A+B+m+2\frac{1}{4}$ oz..

In order to avoid troublesome computations in adjusting the quantities of matter moved and the moving forces, some determinate weight of convenient magnitude may be assumed as a standard, to which all the others are referred. This standard weight in the subsequent experiments is $\frac{1}{4}$ of an ounce, and is represented by the letter m. The inertia of the wheels being therefore $=2\frac{3}{4}$ ounces, will be denoted by $11\ m$. A and B are two boxes constructed so as to contain different quantities of matter, according as the experiment may require them to be varied: the weight of each box, including the hook to which it is suspended, $=1\frac{1}{2}$ oz. or, according to the preceding estimation, the weight of each box will be denoted by $6\ m$; these boxes contain such weights as are represented by fig. 3. each of which weighs an ounce, so as to be equivalent to $4\ m$; other weights of $\frac{1}{2}$ oz. $=2\ m$, $\frac{1}{4}=m$, and aliquot parts of m, such as $\frac{1}{2}m$, $\frac{1}{4}\ m$, may be also included in the boxes, according to the conditions of the different experiments hereafter described.

Fig. 3.

If $4\frac{3}{4}$ oz. or $19\ m$, be included in either box, this with the weight of the box itself will be $25\ m$; so that when the weights A and B, each being $25\ m$, are balanced in the manner above represented, their whole mass will be $50\ m$, which being added to the inertia of the wheels $11\ m$, the sum will be $61\ m$. Moreover, three circular weights, such as that which is represented at fig. 4. are constructed; each of which $=\frac{1}{4}$ oz. or m: if one of these be added to A and one to B, the whole mass will now become $63\ m$, perfectly in equilibrio, and moveable by the least weight added to either (setting aside the effects of friction), in the same manner precisely as if the same weight or force were applied to communicate motion to the mass $63\ m$, existing in free space and without gravity.

462. 2. *The moving force.* Since the weight of any substance is constant, and the exact quantity of it easily estimated, it will be convenient here to apply a weight to the mass A as a moving force: thus, when the system consists of a mass$=63\ m$, according to the preceding description, the whole being perfectly balanced, let a weight $\frac{1}{4}$ oz. or m, such as is represented in fig. 5. be applied on the mass A; this will communicate motion to the whole system; by adding a quantity of matter m to the former mass $63\ m$, the whole quantity of matter moved will now become $64\ m$; and the moving force being $=m$, this will give the force which accelerates the descent of $A=\frac{m}{64\ m}$, or $\frac{1}{64}$ part of the accelerating force of gravity.

Fig. 5.

By the preceding construction, the moving force may be altered without altering the mass moved; for suppose the three weights m, two of which are placed on A and one on B, to be removed, then will A balance B. If the weights $3\ m$ be all placed on A, the moving force will become $3\ m$, and the mass moved $64\ m$ as before, and the force which accelerates the descent of $A=\frac{3\ m}{64\ m}=\frac{3}{64}$ parts of the force by which gravity accelerates falling bodies.

Suppose it were required to make the moving force $2\ m$, the mass moved continuing the same. Let the three weights, each of which $=m$, be removed; A and B will balance each other; and the whole mass will be $61\ m$: let $\frac{1}{2}m$, fig. 5. be added to A, and $\frac{1}{2}\ m$ to B, the equilibrium will be preserved, and the mass moved will be $62\ m$; now let $2\ m$ be added to A, the moving force will be $2\ m$; and the mass moved $64m$ as before; wherefore the force of acceleration $=\frac{1}{32}$ part of the acceleration of gravity. These alterations in the moving force may be easily made in the more elementary experiments, there being no necessity for altering the contents of the boxes A and B: but the proportion and absolute quantities of the moving force and mass moved, may be of any assigned magnitude, according to the conditions of the proposition to be illustrated. Fig. [5.]

463. 3. *Of the space described.* The body A, fig. 1. descends in a vertical line; and a scale about 64 inches in length divided into inches and tenths of an inch is adjusted vertical, and so placed that the descending weight A may fall in the middle of a square stage, fixed to receive it at the end of the descent: the beginning of the descent is estimated from 0 on the scale, when the bottom of the box A is on a level with 0. The descent of A is terminated when the bottom of the box strikes the stage, which may be fixed at different distances from the point 0; so that by altering the position of the stage, the space described from rest may be of any given magnitude less than 64 inches. Fig. 1.

464. 4. *The time of description* is observed by a pendulum, vibrating seconds; and the experiments intended to illustrate the elementary propositions, may easily be so constructed that the time of motion shall be a whole number of seconds. The estimation of the time, therefore, admits of considerable exactness, provided the observer takes care to let the bottom of the box A begin its descent precisely at any beat of the pendulum; then the coincidence of the stroke of the box against the stage, and the beat of the pendulum at the end of the time of motion, will show how nearly the experiment and the theory agree. There might be various devices for letting the weight A begin its descent at the instant of a beat of the pendulum W; for instance, let the bottom of the box A, when at 0 on the scale, rest on a flat rod, held in the hand horizontally; its extremity being coincident with 0, by attending to the beats of the pendulum; and with a little practice, the rod which supports the box A may be removed at the moment the pendulum beats, so that the descent of A shall commence at the same instant.

465. 5. *Of the velocity acquired.* It remains only to describe in what manner the velocity acquired by the descending weight A, at any given point of its path, is made evident to the senses. The velocity of A's descent being continually accelerated will be the same in two points of the space described. This is occasioned by the constant action of the moving force; and since the velocity of A at any instant is measured by the space which

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which would be described by it moving uniformly for a given time with the velocity it had acquired at that instant, this measure cannot be experimentally obtained, except by removing the force by which the descending body's acceleration was caused.

In order to show in what manner this is effected particularly, let us again suppose the boxes A and B $=25m$ each, so as together to be $=50m$; this with the wheel's inertia $11m$ will make $61m$; now let m be added to A, and an equal weight m to B, these bodies will balance each other, and the whole mass will be $63m$. If a weight m be added to A, motion will be communicated, the moving force being m, and the mass moved $64m$. In estimating the moving force, the circular weight $=m$ was made use of as a moving force: but for the present purpose of showing the velocity acquired, it will be convenient to use a flat rod, the weight of which is also $=m$. Let the bottom of the box A be placed on a level with 0 on the scale, the whole mass being as described above $=63m$, perfectly balanced. Now let the rod, the weight of which $=m$, be placed on the upper surface of A; this body will descend along the scale in the same manner as when the moving force was applied in the form of a circular weight. Suppose the mass A, fig. 6. to have descended by constant acceleration of the force of m, for any given time, or through a given space: let a circular frame be so affixed to the scale, contiguous to which the weight descends, that A may pass centrally through it, and that this circular frame may intercept the rod m by which the body A has been accelerated from rest. After the moving force m has been intercepted at the end of the given space or time, there will be no force operating on any part of the system which can accelerate or retard its motion: this being the case, the weight A, the instant after m has been removed, must proceed uniformly with the velocity which it had acquired that instant: in the subsequent part of its descent, the velocity being uniform will be measured by space described in any convenient number of seconds. (Fig. 6.)

466. Mr Atwood's machine is also useful for estimating experimentally the velocities communicated by the impact of bodies elastic and nonelastic; the quantity of resistance opposed by fluids, as well as for various other purposes. These uses we shall not insist on; but the properties of retarded motion being a part of the present subject, it may be necessary to show in what manner the motion of bodies resisted by constant forces are reduced to experiment by means of the instrument above described, with as great ease and precision as the properties of bodies uniformly accelerated. A single instance will be sufficient: Thus, suppose the mass contained in the weights A and B, fig. 6. and the wheels to be $61m$, when perfectly in equilibrio; let a circular weight m be applied to B, and let two long weights or rods, each $=m$, be applied to A, then will A descend by the action of the moving force m, the mass moved being $64m$: suppose that when it has described any given space by constant acceleration, the two rods m are intercepted by the circular frame above described, while A is descending through it, the velocity acquired by that descent is known; and when the two rods are intercepted, the weight A will begin to move on with the velocity acquired, being now retarded by the constant force m; and since the mass moved is $62m$, the force of retardation will be $\frac{1}{62}$ part of that force whereby gravity retards bodies thrown perpendicularly upwards. The weight A will therefore proceed along the graduated scale in its descent, with an uniformly retarded motion, and the spaces described, times of motion, and velocities destroyed by the resisting force, will be subject to the same measures as in the examples of accelerated motion already described.

In the preceding descriptions, two suppositions have been assumed, neither of which is mathematically true: but it might be easily shown that they are so in a physical sense; the errors occasioned by them being insensible in practice.

2. *Machine for illustrating the Theory of the Wedge.*

467. This machine is represented in fig. 7. where KILM and LMNO are two flat pieces of wood joined together by a hinge at LM; P is a graduated arch on which these pieces of wood can be moved so as to subtend any angle not greater than 60°, and a, b two screws for fixing them at the required angle. The back of the wedge will therefore be represented by IKNO, its sharp edge by LM, and its two sides by KILM, LMNO. The weight p suspended to the wedge by the hook M, and the weight of the wedge itself, may be considered as the force employed to drive the wedge. The wooden cylinders AB, CD, have their extremities made like two flat circular plates to prevent the wedge from slipping off at one side. To the pivots of these cylinders, two of which are represented at e and f, are fastened the cords eW, fU, CV, AX, which passing over the pulleys U, V, X, W are fastened to the two bars $u\,v$, $x\,w$, on which any equal weights Y, Z may be hung at pleasure. The tendency of these weights is evidently to draw the cylinders towards each other, and they may therefore be regarded as the resistance of the wood acting against the sides of the wedge. The cylinders themselves are suspended by their pivots to the threads E, F, G, H, which may be fixed to the ceiling of the room, or to the horizontal beam of a frame made on purpose.—By placing various equal weights at Y and Z, it may be easy to determine the proportion between the power and the resistance when the wedge is in equilibrio.—In this machine the impelling power is the pressure of the weight p, whereas, in the real wedge, the impelling power is always an impulsive force which is infinitely more powerful. (Plate CCCXXVI. fig. 7.)

3. *Machine far illustrating the effects of the centrifugal force in flattening the poles of the Earth.*

468. Fig. 8. represents this machine, which consists of two flexible circular hoops, AB and CD, crossing one another at right angles, and fixed to the vertical axis EF at its lower extremity, but left loose at the pole or intersection e. If this axis be made to revolve rapidly by means of the winch m, and the wheel and pinion n, o, the middle parts A, B, C, D will, by their centrifugal force, swell out and strike against the frame at F and G; if the pole e, when sinking, is not stopped by means of a pin E fixed in the vertical axis. The hoops, therefore, will have a spheroidal form; the equatoreal being larger than the polar diameter. (Fig. 8.)

Machine for trying the strength of materials.

4. *Machine for trying the Strength of Materials.*

469. The piece of wood, whose strength is to be tried,

D·ription of M·chines. Plate ·XXVII. ·g. 1.

tried, is represented by EF, and the force is applied to it by means of the winch A, which winds up the rope BC, passing over the pulley n, and below the pulley m, and attached to the point D of the beam EF. The pulleys slide on two parallel bars fixed in a frame, held down by a projecting point, at G, of the lever GR, which is graduated like a steelyard, and measures the force employed. The beam EF is held by a double vice IK with four screws, two of which are invisible. When a wire is to be torn it is fixed to the cross bar LM; and when any body is to be crushed, it must be placed beneath the lever NO, the rope BC being fixed to the hook N, and the end O being held down by the click which acts on the double ratchet OP.—The lever is double from O to Q, and acts on the body by a loop fixed to it by a pin. See *Young's Nat. Philos.* vol. i. p. 768. from which this drawing and description are taken.

5. *Machine in which all the Mechanical powers are combined.*

C·bina·ti· of all ·necha·nical pow·ers. F· 2.

470. The lever AB, whose centre of motion is C, is fixed to the endless screw DE, which drives the wheel and axle FHG. Round the axle G is coiled a rope GHI, which passes round the four pulleys K, L, m, n, and is fixed to a hook at m on the lower block, which carries the weight W. When equal weights are suspended on the lever at equal distances from the fulcrum C, the lever becomes a balance, and the wedge and inclined plane are evidently included in the endless screw DE. If the wheel F has 30 teeth, if the lever AB is equal to twice the diameter of the wheel FH, and if the diameter of the axle G is one-tenth of the diameter of the wheel, a power of 1 exerted at P will raise a weight of 2400, suspended at the lower block of the four pulleys.

6. *Fidler's Balance.*

F·er's ba·la·e. F· 3.

471. The balance represented in fig. 3. was made by Fidler for the Royal Institution, and does not differ much from those which have been constructed by Ramsden and Troughton. The middle column A can be raised at pleasure by the nut B, and supports the round ends of the axis in the forks at its upper extremity, in order to remove the pressure on the sharp edges of the axis within the forks. C and D are pillars which occasionally support the scales, and may be elevated or depresed by turning the nut E. The screw F raises or depresses a weight within the conical beam, for the purpose of regulating the position of the centre of gravity. The graduated arc G measures the extent of the vibrations. See *Young's Nat. Philos.* vol. i. p. 765.

7. *Improvement on the Balance.*

I·rove·m·t on t· ba·la·e. F· 5.

472. An improvement on the balance is represented in fig. 4. where DC is a micrometer screw fixed to the arm FA, so that when it is turned round by the nut D, it neither approaches to, nor recedes from, the centre of motion F. The screw DC works in a female screw in the small weight n, and by revolving in one direction, carries this weight from S to R, and thus gives the preponderance to the scale G. The recession of the weight n from the centre F is measured as in the common micrometer, and a weight x placed in the scale suspended at A, will be in equilibrio with n placed at any distance S n, when $x = \frac{S\,n \times n}{FA}$.—*Appendix to Ferguson's Lectures.*

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8. *Machine for shewing the Composition of Forces.*

Machine for the composition of forces. Fig. 4.

473. The part BEFC is made to draw other parts into the wooden square ABCD. The pulley H is joined to BEFC so as to turn on an axis which will be at H when the square BEFC is pushed in, and at p when it is drawn out. A ball G is made to slide on the wire k which is fixed to BEFC, and the thread m attached to the ball goes over the pulley to I, where it is fixed. Now, when the piece BEFC is pulled out, the pulley, wire, and ball, move along with it, in the direction DCF, and it is evident that the ball G will slide gradually up the wire k. It is therefore acted upon by two forces: one in the direction GH, and the other in the direction GC, and will be found at the end of the motion at g, having moved in the direction G g, the diagonal of a parallelogram whose sides are GH, GC.

9. *Smeaton's Machine for experiments on Windmill Sails.*

Apparatus for windmills. Fig. 6.

474. In the experiments with this machine, the sails were carried round in the circumference of a circle, so that the same effect was produced as if the wind had struck the sails at rest with the velocity which was then given them. In the pyramidal frame ABC is fixed to the axis DE, which carries the arm FG with the sails GI. By pulling the rope Z, which coils round the barrel H, a motion of rotation is given to the sails, so that they revolve in the circumference of a circle, whose radius is DI. At L is fixed a cord which passes round the pulleys M, N, O, and coils round a small cylinder on the axis of the sails and raises the scale C, in which different weights are placed for trying the power of the sails, and which, being in the direction of the axis DE, is not affected by the circular motion of the arm DG. The scale C is kept steady by the pillars Q, R, and prevented from swinging by the chains S, T, which hang loosely round the pillars. VX is a pendulum composed of two leaden balls moveable upon a wooden rod, so that they can be adjusted to vibrate in any given time. The pendulum hangs upon a cylindrical wire, on which it vibrates as on a rolling axis.

10. *Smeaton's Machine for experiments on Rotatory Motion.*

Apparatus for rotatory motion. Plate CCCXXVIII. Fig. 1.

475. This machine is exhibited in fig. 1. where the vertical axis NB is turned by the rope M passing over the pulley R, and carrying the scale S. The axis NB carries two equal leaden weights K, D, moveable at pleasure on the horizontal bar HI. The upper part N of the axis is one half the diameter of the part M, so that when the rope is made to wind round N, it acts at half the distance from the axis, at which it acts when coiled round M.—When the rope is wound round N, the same force will produce in the same time but half the velocity which is produced when the rope coils round M, the situation of the leaden weights being the same: But when the weights K, L are removed to a double distance from the axis, a quadruple force will be required in order to produce an equal angular velocity in a given time.

CHAP.

Description of Machines.

Chap. II. *Machines for various purposes.*

1. *Prony's Condenser of Forces.*

Prony's condenser of forces. Plate CCCXXVIII. fig. 2, 3.

476. The object of this machine is to obtain a maximum effect from an impelling power which is subject to variation in its intensity. Let us suppose that wind is the first mover, and that O, O is the vertical axis of a windmill; *c*, *c*, *c*, *c*, are several radii issuing from this axis, and carrying a wiper *b d*, which acts upon the corresponding wipers *a f*, and gives a motion of rotation to the axis *a*, *a*, *a*, *a*, to which they are attached. The wipers *b d*, *a f* must be so constructed that when *b d* ceases to press on one wiper *a f*, it shall at the same moment begin to act upon the next wiper. Each of the axes, *a*, *a*, *a*, *a*, carries a drum *t t r r*, round which is coiled a cord *t p* F, passing over the pulley *p*, and supporting a weight Q which can be placed at different distances from G on the lever FG. The axes *a*, *a*, *a*, *a* also pass through the pinions *q q*, to which they are not fixed; but these pinions carry ratchet wheels that bear against the teeth *r r*, so that when the weight Q rises, the rope merely coils round the drum without moving the pinion *q q*. But when the wiper *b d* ceases to act upon *a f*, the weight Q descends, and then the toothed wheel *r r* acts against the ratchet, so that Q cannot descend without turning the pinion *q q* along with the drum. The pinion *q q* drives the wheel *a b*, which again drives the wheel CE by means of the bevelled teeth CD, and elevates the load at P. Hence, when the axis OO is put in motion by the wind acting on the sails, it will first raise a number of weights Q sufficient to put the machine in motion, and will continue to raise new weights while those before raised are fallen, so that the motion once impressed will be continued.

2. *Portable Stone Crane, for loading and unloading Carts.*

Portable stone crane. Fig. 4.

477. This crane is mounted on a wooden stage, and is so constructed that it may be taken to pieces. The frame A, A, A, A is about ten feet high, nine feet long and nine feet wide. The wheels B, B are of iron, and about three feet in diameter. The pinion D that is fixed to the axis of the first wheel B is eight inches diameter, and the other pinion C is about the same diameter. When the stones are suspended to the rope that coils round the barrel, the workman turns a winch on the axis of the wheel C, and raises or lowers the weight according to the direction in which he turns it.

3. *Portable Cellar Crane.*

Portable cellar crane. Fig. 5.

478. This crane is represented in fig. 5. where A, A are two wooden supports about six feet high, which are joined at E, and connected by the iron cylinder C and the wooden bar D. The supports A, A are fastened to the edge of the cellar by the iron prongs E, E, and the two ropes which support the barrel and pass round it are fixed to the iron clamp G, G. These ropes coil round the cylindrical bar F, which is put in motion by the winch K, driving the pinion I about four inches diameter, which gives motion to the wheel H, about three feet in diameter. The barrel, therefore, will rise or fall according to the direction in which the winch is moved.

4. *Weighing Crane.*

Plate CCCXXX. fig. 6. Andrews' weighing crane.

479. This crane represented in fig. 6. was invented by Mr Andrews, and weighs the body at the time that it is raising it. The weight W is elevated by means of the levers M, N, O, P which coil the rope HR round the barrel H. The jib ED stands on a horizontal beam moveable in a vertical plane round the centre FA, and the distance of the upright beam F from the centre of motion A is $\frac{1}{20}$ of BF. The weight of the body W is then ascertained by the weight at B, which keeps it in equilibrio. The piece of wood C projects from the vertical beam CT, in order to prevent the beam from rising too high.

5. *Gilpin's Crane.*

Gilpin's crane. Plate CCCXXIX. fig. 1, 2, 4, 5.

480. In fig. 1. where this machine is represented, AB is the perpendicular stand, formed of two oaken planks let into cast iron mortises C, D: Between these planks is fixed the barrel E with spiral grooves on its surface, on which the chain RL winds. When the winch N is put in motion it drives the pinion O, which again drives the wheel P, on whose axis is fixed the barrel F, so that the chain is coiled round the barrel and the weight raised. A section of this part of the machinery is shewn in fig. 2. Figure 3. shews an enlarged view of part of the barrel, and part of the chain lying in its proper position in the spiral grooves or channels. In order to prevent the chain from twisting when it is wound upon the barrel, the lower edge of one link lies in the groove, and the next link upon the surface of the barrel. This will be better understood from fig. 4. which is a section of the barrel F, and shews the manner in which one link lies within it, and the other link on its outside. The old method of working chains is exhibited in fig. 5. For a full account of this useful invention, see Nicholson's Journal, vol. xv. p. 126.

6. *Bramah's Jib for Cranes.*

Bramah's jib. Fig. 6.

481. The nature of this invention, for which we are indebted to the ingenious Mr Bramah, may be easily understood from a bare inspection of fig. 6. which represents a jib attached to the wall of a warehouse. The jib turns on a perforated axis or pillar. The rope by which the weight is raised, after passing over two pulleys, goes through the perforated axis, and is conducted over another pulley to the barrel of the crane, which is not represented in the figure. In jibs of the common construction which turn in two solid gudgeons, the rope passes over the upper gudgeon, and is confined between two vertical rollers; but the bending of the rope occasions a great deal of friction, and produces a constant effort to bring the arm of the jib into a position parallel to the inner part of the rope.

7. *Gottlieb's Carriage Crane.*

Plate CCCXX[illegible] fig. 7. Carriage crane.

482. This machine, which is useful for carrying large stones where carts and horses cannot be easily obtained, consists of two sorts of crane wheels applied to the two sets of wheels belonging to the carriage, so that two men, one acting at each winch A, A give motion to the loaded carriage. The pinion B, six inches in diameter turns the wheel C, three feet in diameter. The wheel C gives motion to the pinion D one foot in diameter,

meter, which works into two wheels E, E three feet six inches diameter, and are fixed on the wheels of the carriage.

8. *Common Jack.*

483. The common worm jack is represented in fig. 8. and is impelled by the weight W, which is suspended to a rope passing through the pulleys V, R, and rolling round the barrel Q. When the barrel is put in motion by the action of the weight, it drives the wheel KL of 60 teeth, by means of a catch fixed to AB, which lays hold of the cross bars in KL. The wheel KL drives the pinion M of 15 teeth, fixed on the axis of the wheel N of 30 teeth, which gives motion to the endless screw O, and the fly-wheel P. On the axis of the wheel KL is fixed the pulley DG, which, by means of a rope, gives motion to the spit. The axis ET is fixed in the barrel AC; and as this axis is hollow, both it and the barrel turn round upon the axis FD, so that the rope may be coiled round the barrel by the winch H without moving the wheel K.

9. *Loading and Unloading Machine.*

484. This portable machine, invented by Mr Davis of Windsor, is put in motion by the winch A, which drives the two endless screws C, C. These screws move the wheels E, E, and consequently the barrels connected with them, so that the ropes F, F passing over the pulleys G, G are coiled round the barrels, and the load H which these ropes support is raised into the frame R, R, which shews a part of the cart. The barrels and wheels are contained in an iron box L, the sides of which are removed in the figure.

10. *Vauloue's Pile Engine.*

485. The horses which work this engine are yoked at S, S, and by moving the wheel B and drum C, which are locked together, raise the follower GH, (carrying the ram Q by the handle R), by means of the rope HH which coils round the drum. When the follower G reaches the top of the frame, the upper legs of the tongs H are closed by pressing against the adjacent beams; and their lower legs are opened, so that they drop the ram Q, which falls and strikes the pile. When G is at the top of the frame, the crooked handle 6, of the follower G, presses against the cords *a*, *a*, which raise the end of the lever L (see fig. 2.) round *m* as a centre, and by depressing the extremity N, and consequently the bar S, S, unlock the drum C and the wheel B, so that the follower G falls by its weight and seizes the ram R. As soon as the follower drops, the horses would tumble down, having no resistance to overcome, were not this prevented by the fly O, which is moved by the wheel B and trundle X, and opposes a sufficient resistance to the horses till the follower again seizes the ram. When the follower falls, the weight L (fig. 2.) pushes up the bolt Y into the drum C, and locks the wheel and the drum;—and the same operation is afterwards repeated. See *Ferguson's Lect.* vol. i. p. 118.

Description of Machines.

11. *Bunce's Pile Engine.*

486. A side view of this engine is shewn in fig. 3, 4. It consists of two endless ropes or chains A, connected by cross pieces of iron B, B, &c. (fig. 4.) which pass round the wheel C, the cross pieces falling into corresponding cross grooves, cut in the periphery of the wheel. When the man at S, therefore, drives the wheel *m* by means of the pinion *p*, he moves also the wheel C fixed on the axis of *m*, and makes the double ropes revolve upon the wheels, C, D. The wheel D is fixed at the end of a lever DHK, whose centre of motion is H, a fixed point in the beam FT. Now, when the ram L (fig. 3, 5.) is fixed to one of the cross-pieces B by the hook M, the weight of the ram, acting by the rope, moves the lever DK round H, and brings the wheel D to G, so that, by turning the winch, the ram L (fig. 3.) is raised in the vertical line LRG. But when it reaches R, the projecting piece R disengages the ram from the cross piece B, by striking the bar Q; and as the weight is removed from the extremity D of the lever, the counterpoise I brings it back from G to its old position at F, and the ram falls without interfering with the chain. When the hook is descending, it is prevented from catching the rope by means of the piece of wood N suspended from the hook M at O; for being specifically lighter than the iron weight L, and moving with less velocity, it does not come in contact with L till the ram is stopped at the end of its path. When N, therefore, falls upon L, it depresses the extremity M of the hook, and therefore brings the hoop over one of the cross pieces B, by which the ram is again raised.

Bunce's pile engine, Fig. 3, 4.

487. For the description of a great variety of useful machines, the reader is referred to the second volume of Mr Gregory's Mechanics, and to Dr Young's Natural Philosophy, a work of great merit, which would have been more particularly noticed if it had reached us before the historical part of this article was printed off.—See also HYDRODYNAMICS, MARLY, *Machine at*, MILL, RAMSDEN, and *WATER-Works*, in this Work, and the articles ATTRACTION and BRIDGE in the Supplement.

INDEX.

Conical

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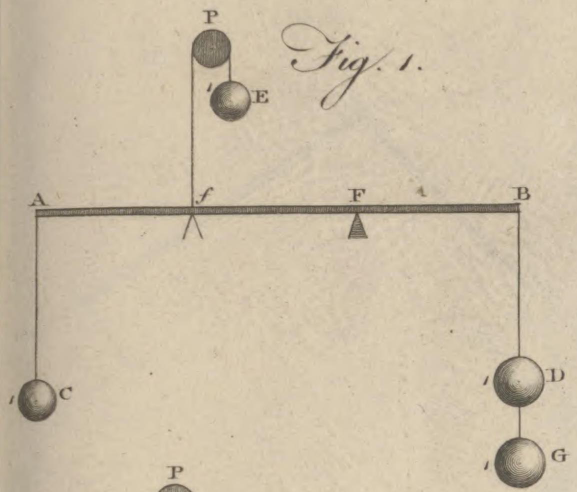
Fig. 1.



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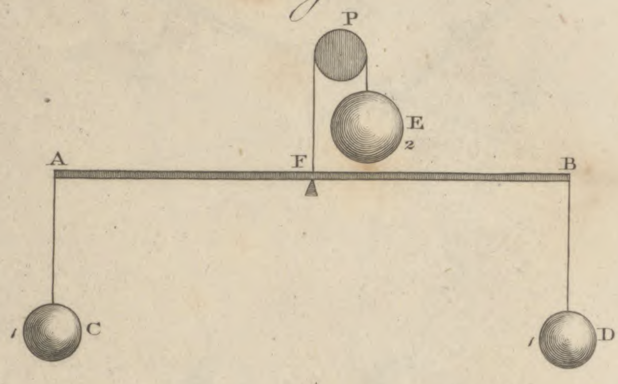

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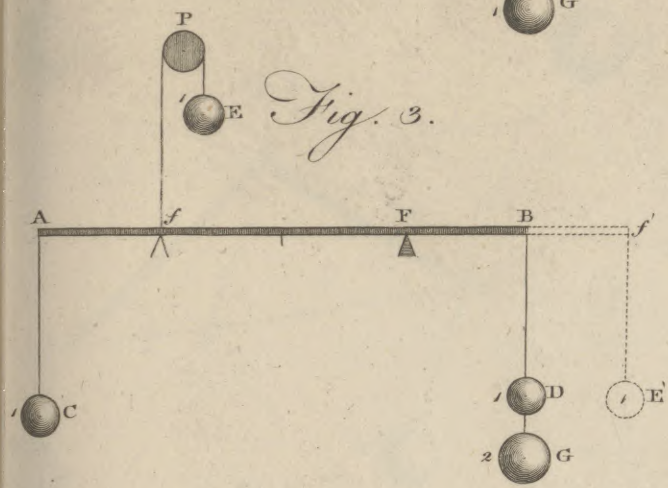

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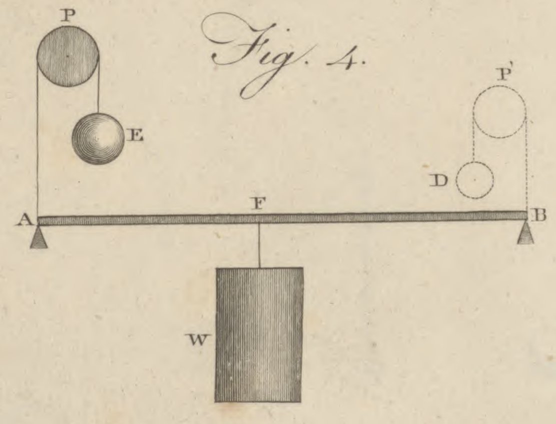

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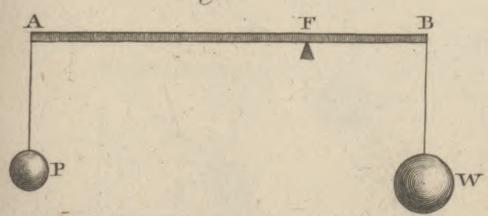

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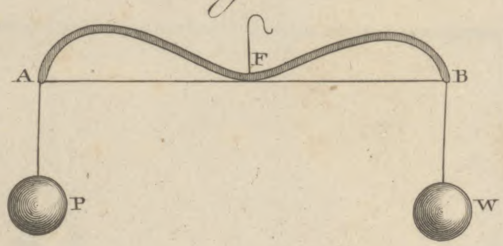

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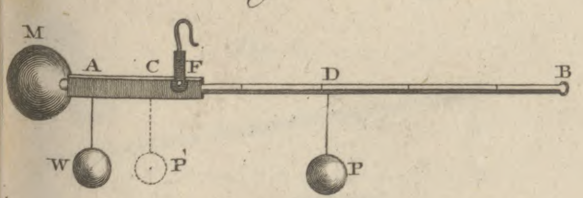

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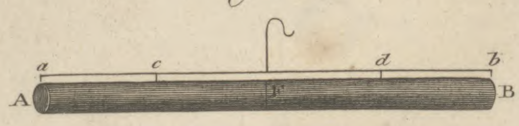

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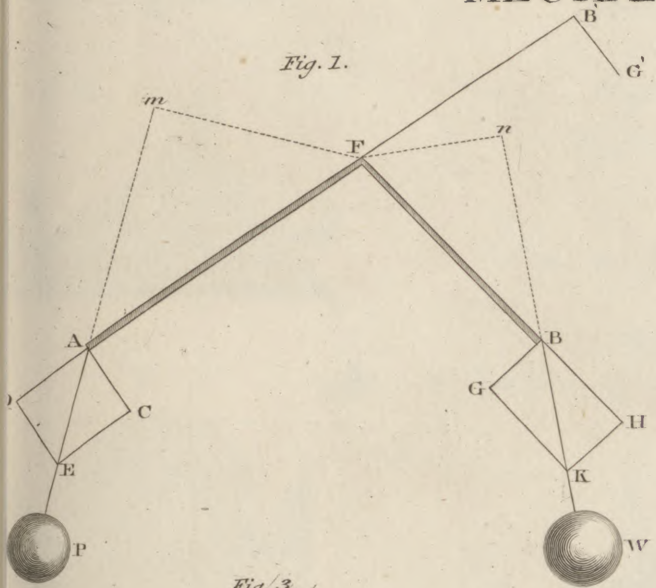

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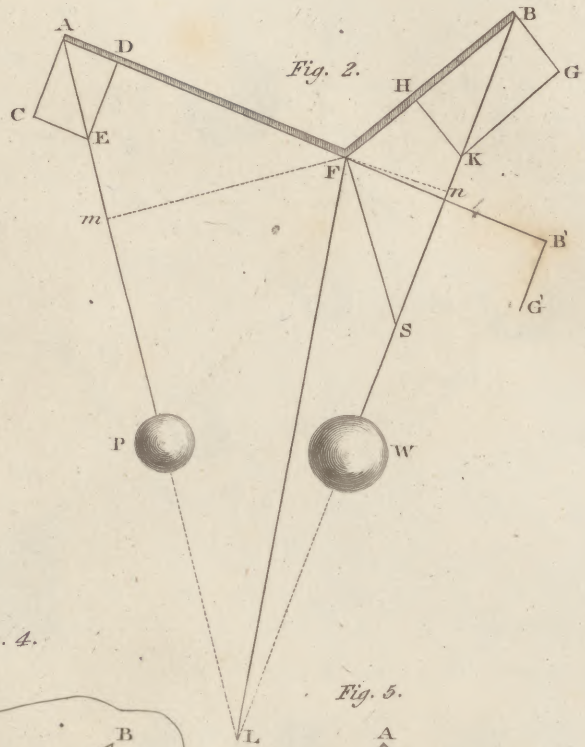

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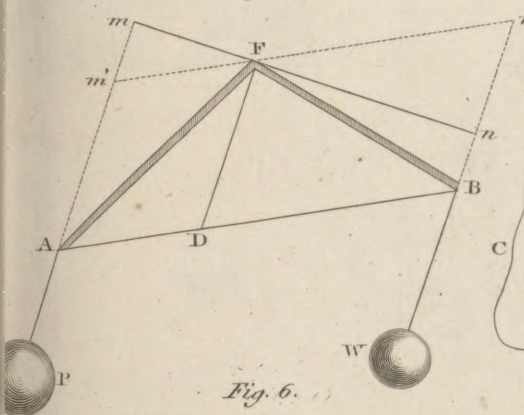

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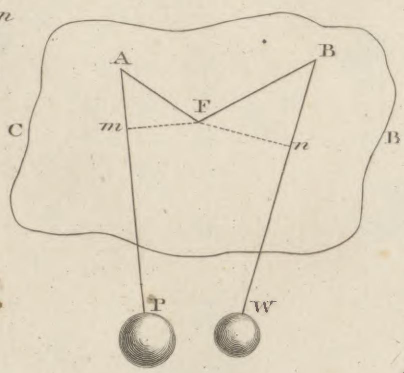

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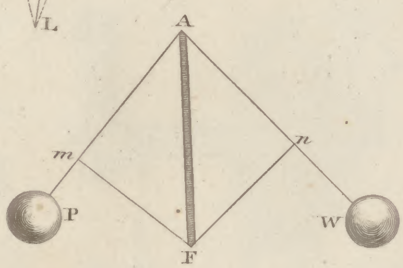

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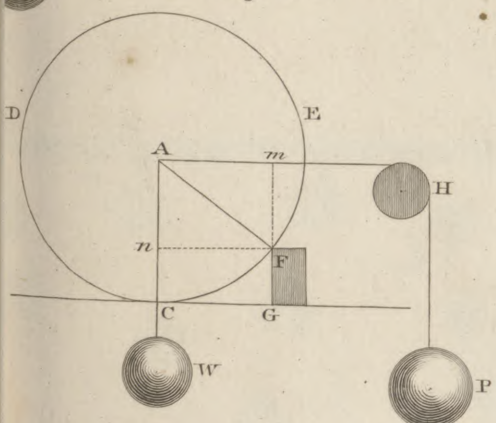

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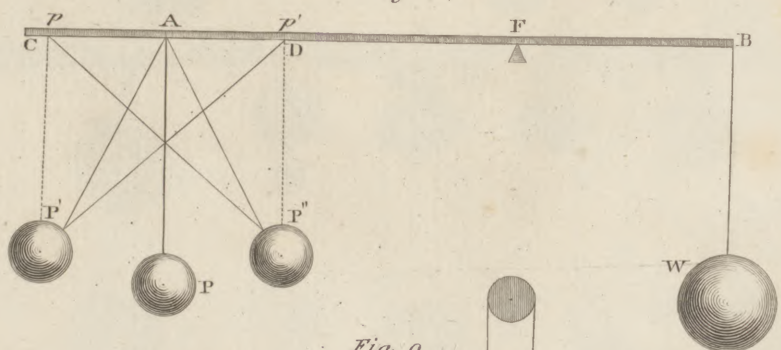

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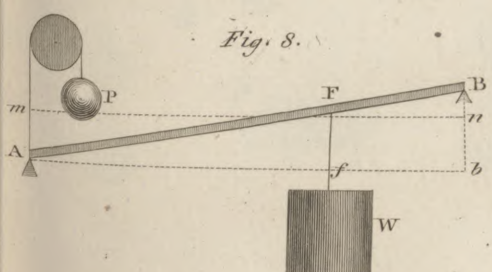

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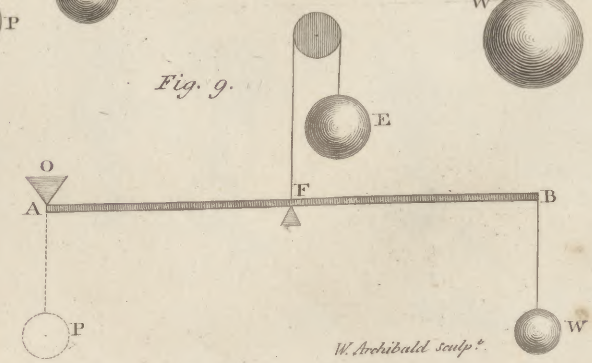

Fig. 9.

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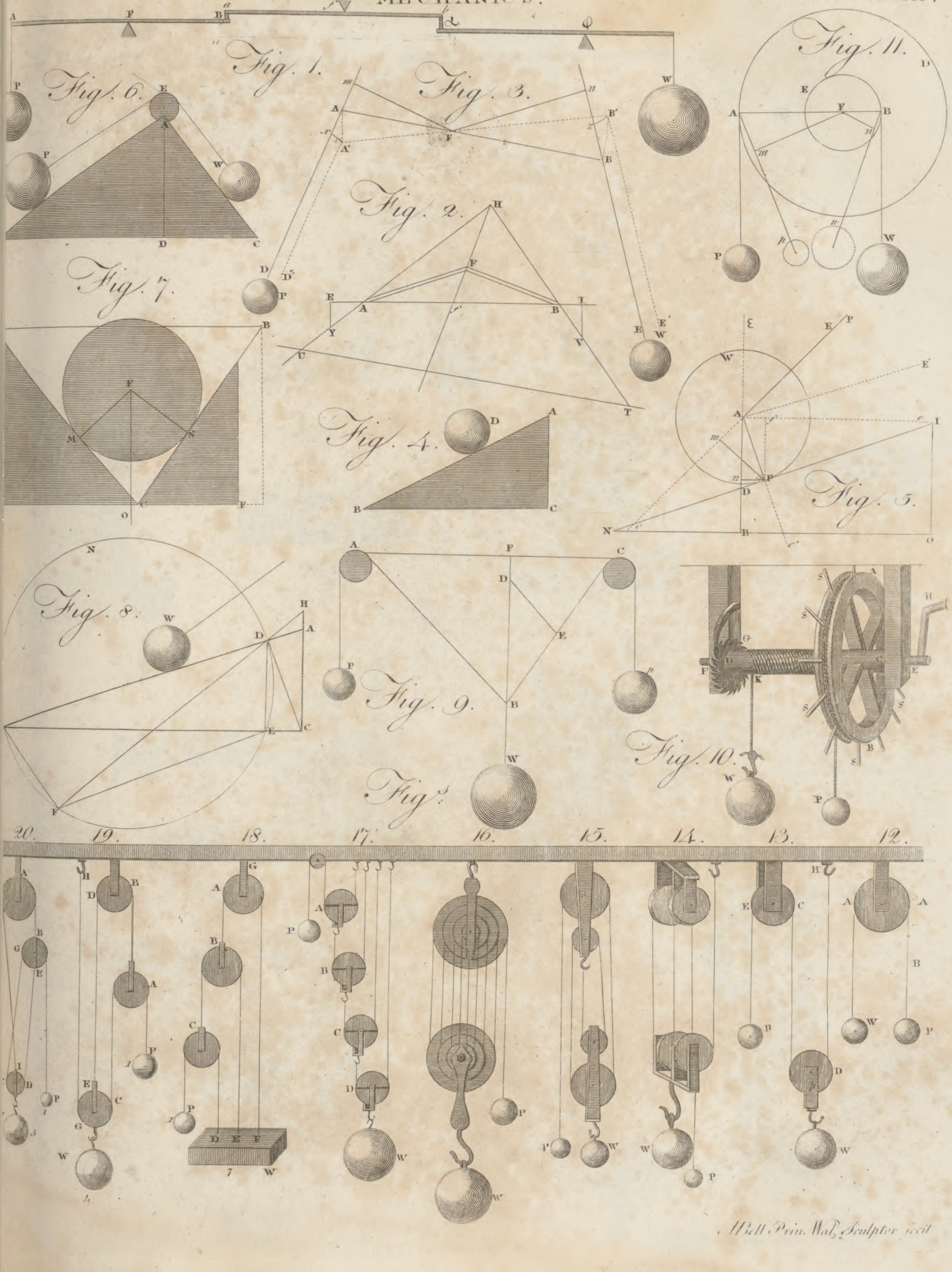

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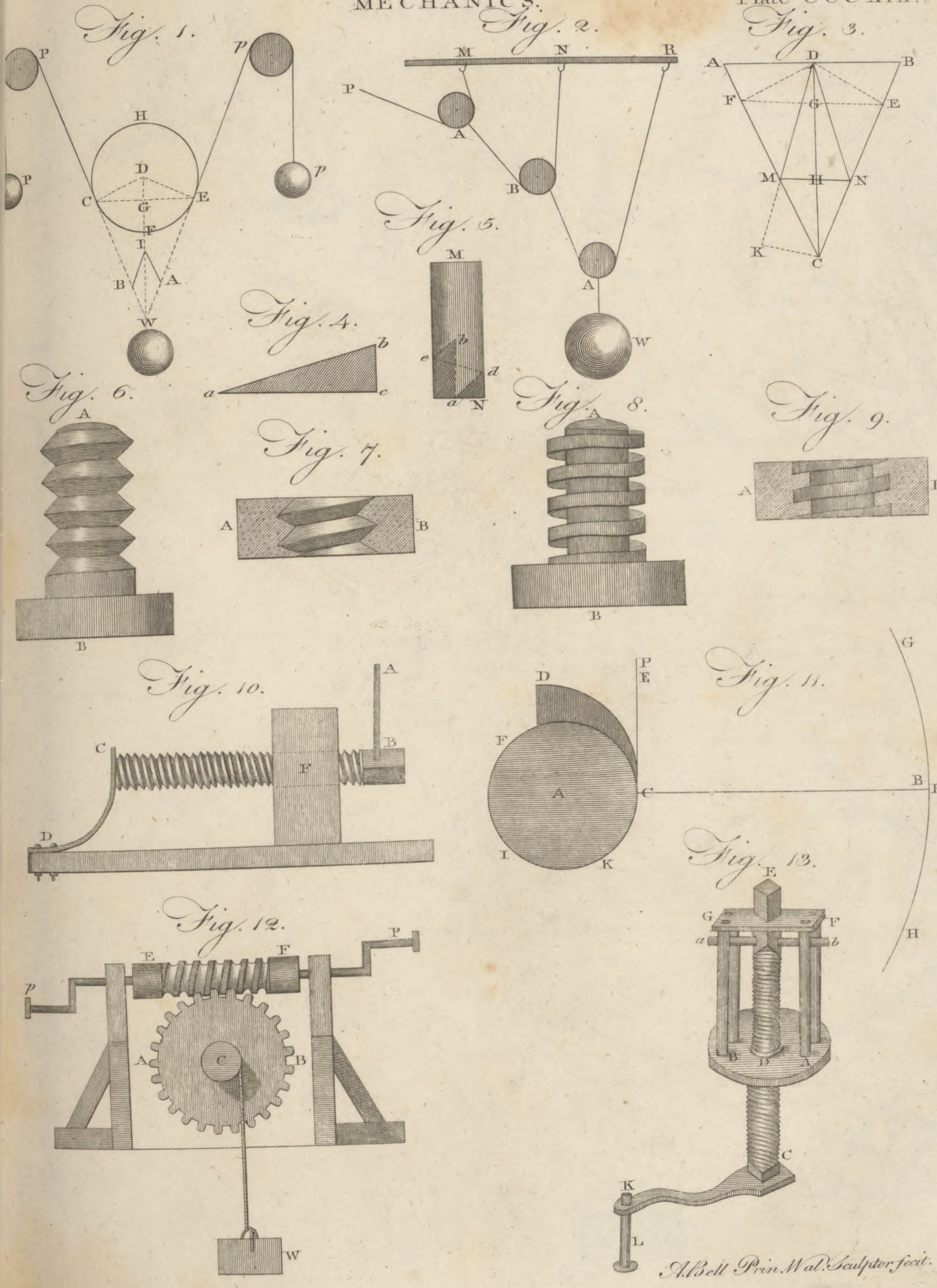

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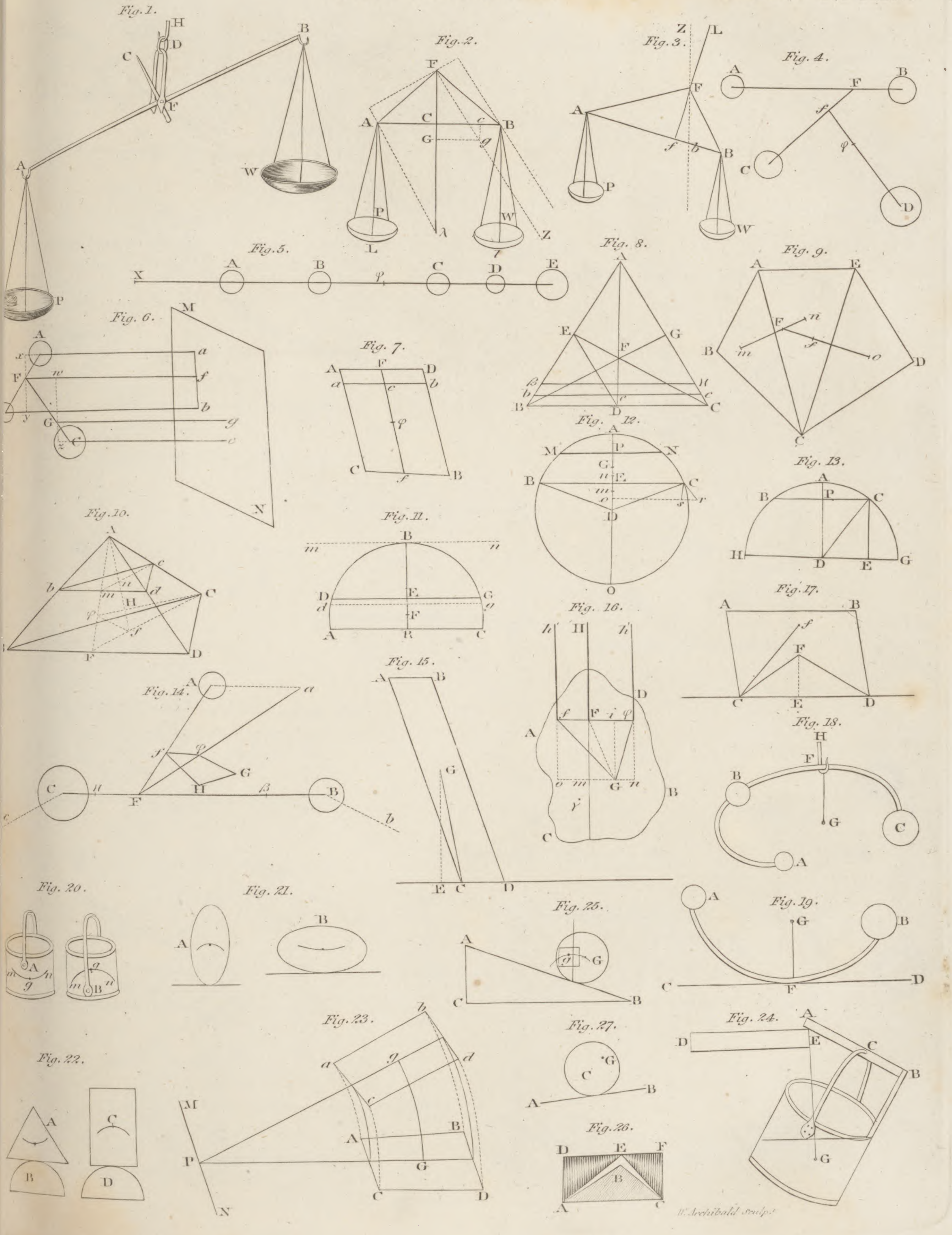

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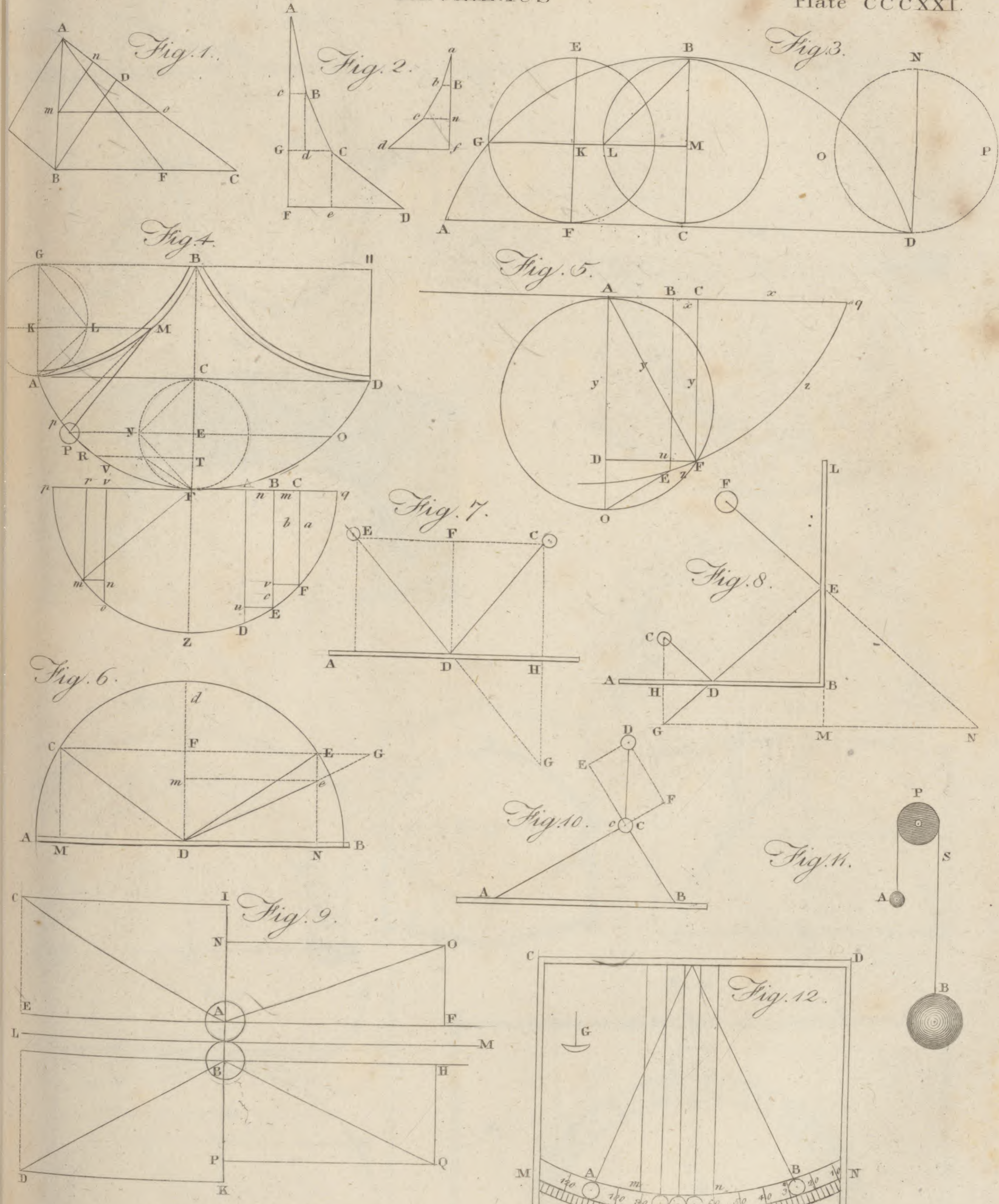

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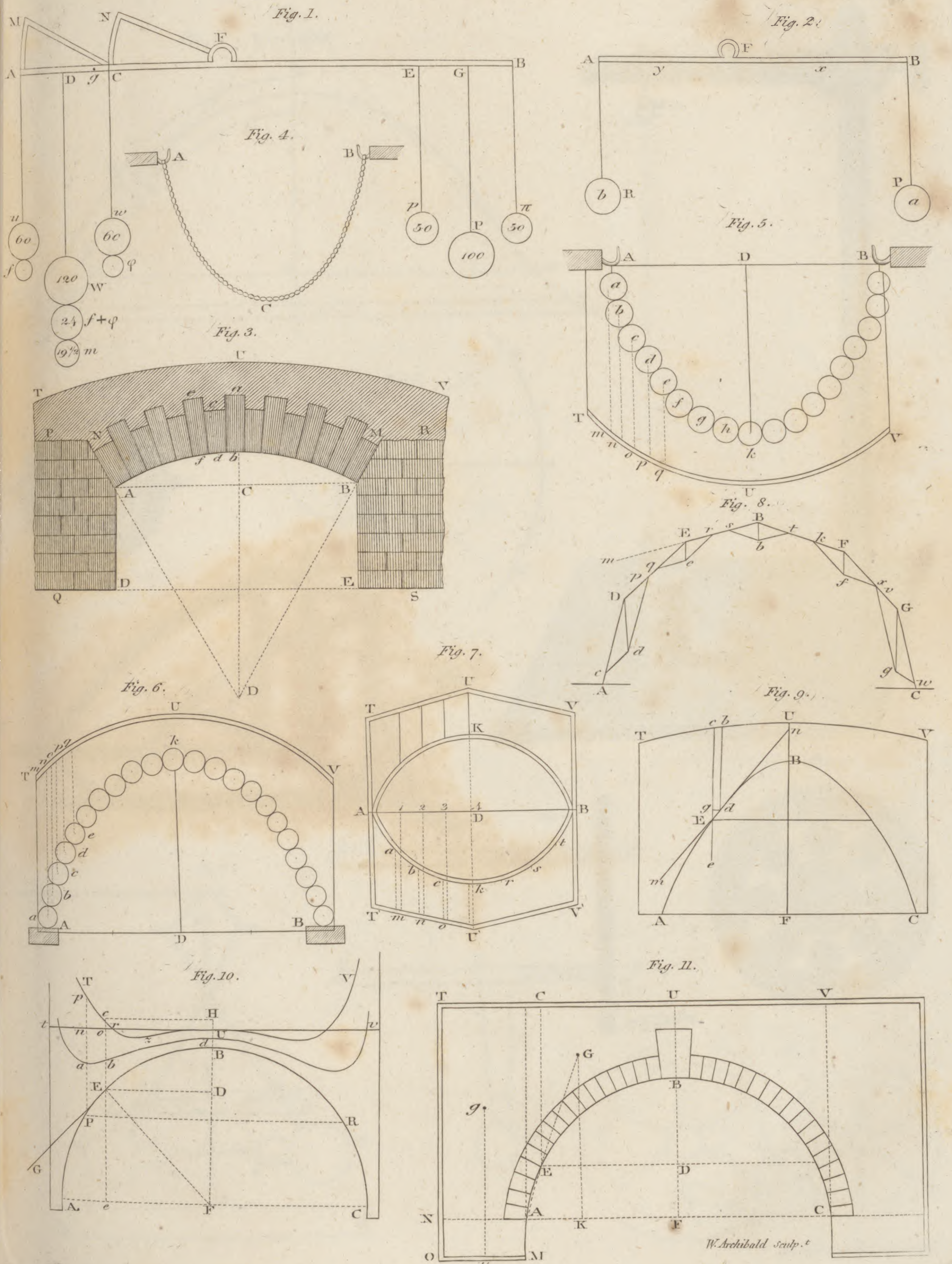
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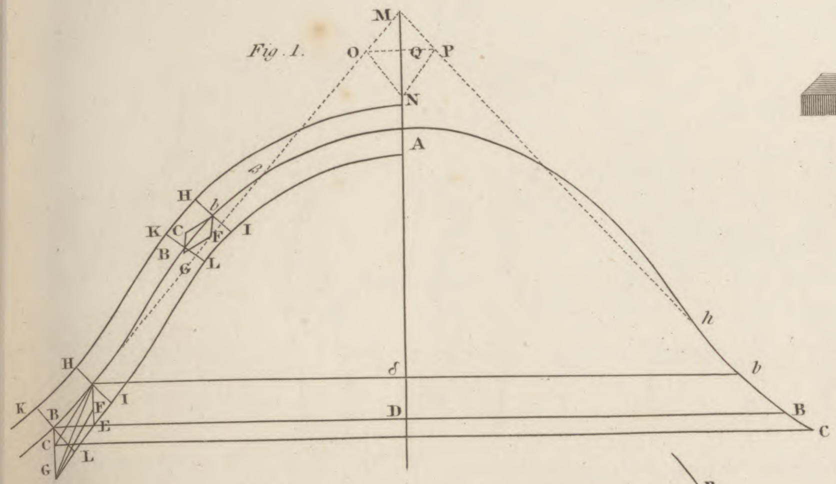

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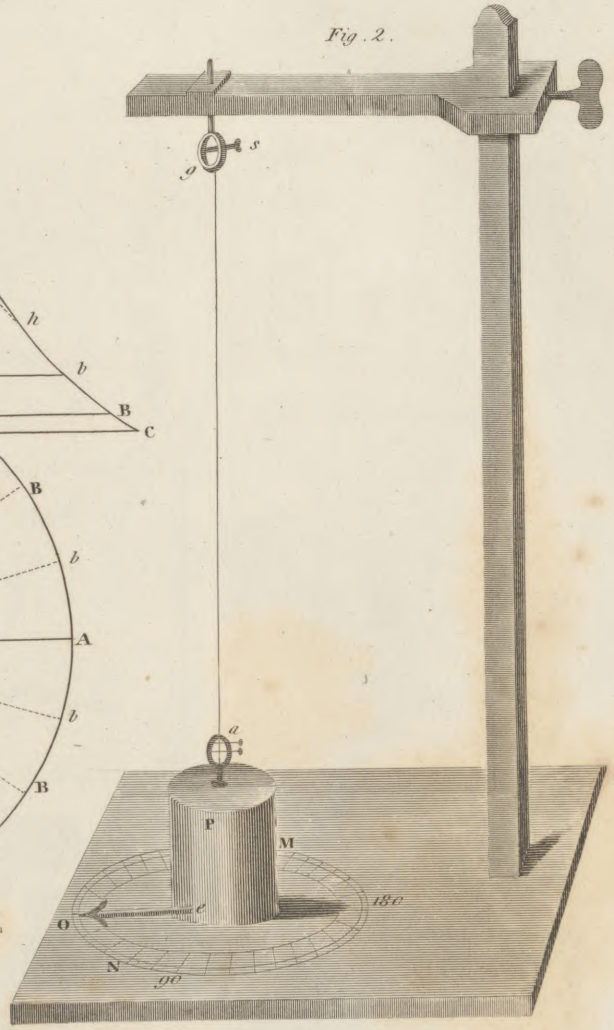

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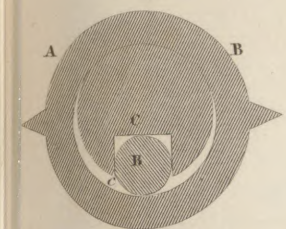

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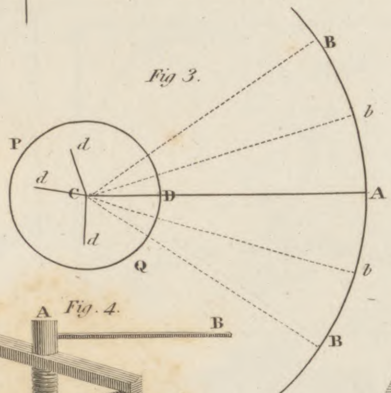

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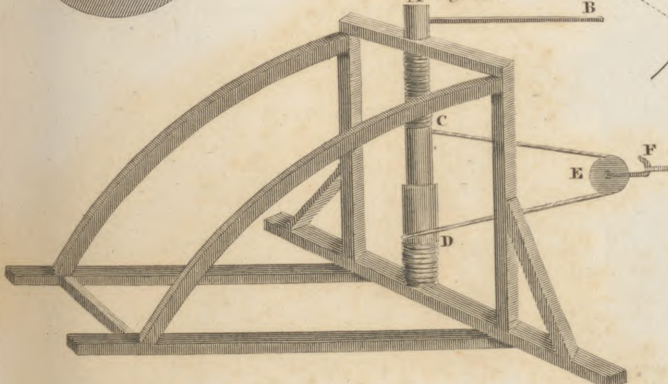

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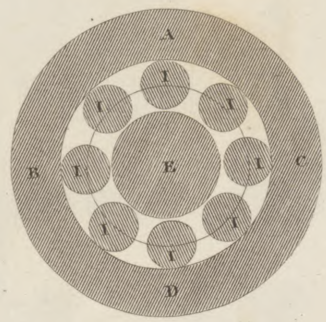

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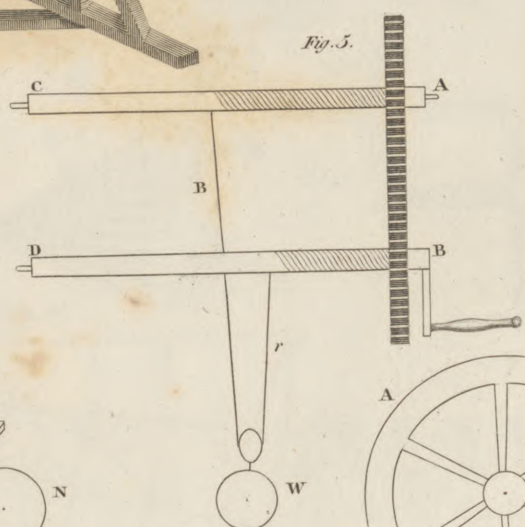

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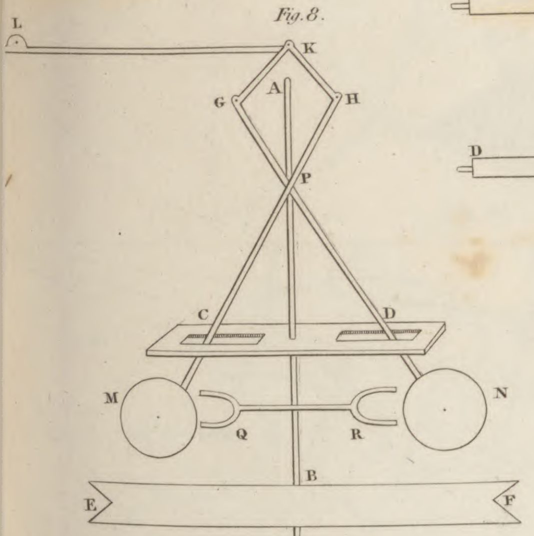

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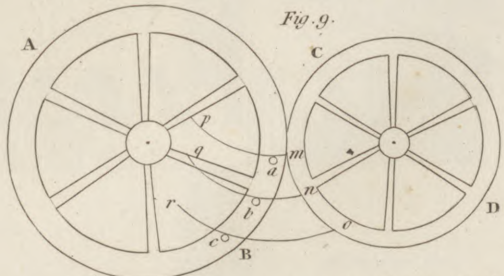

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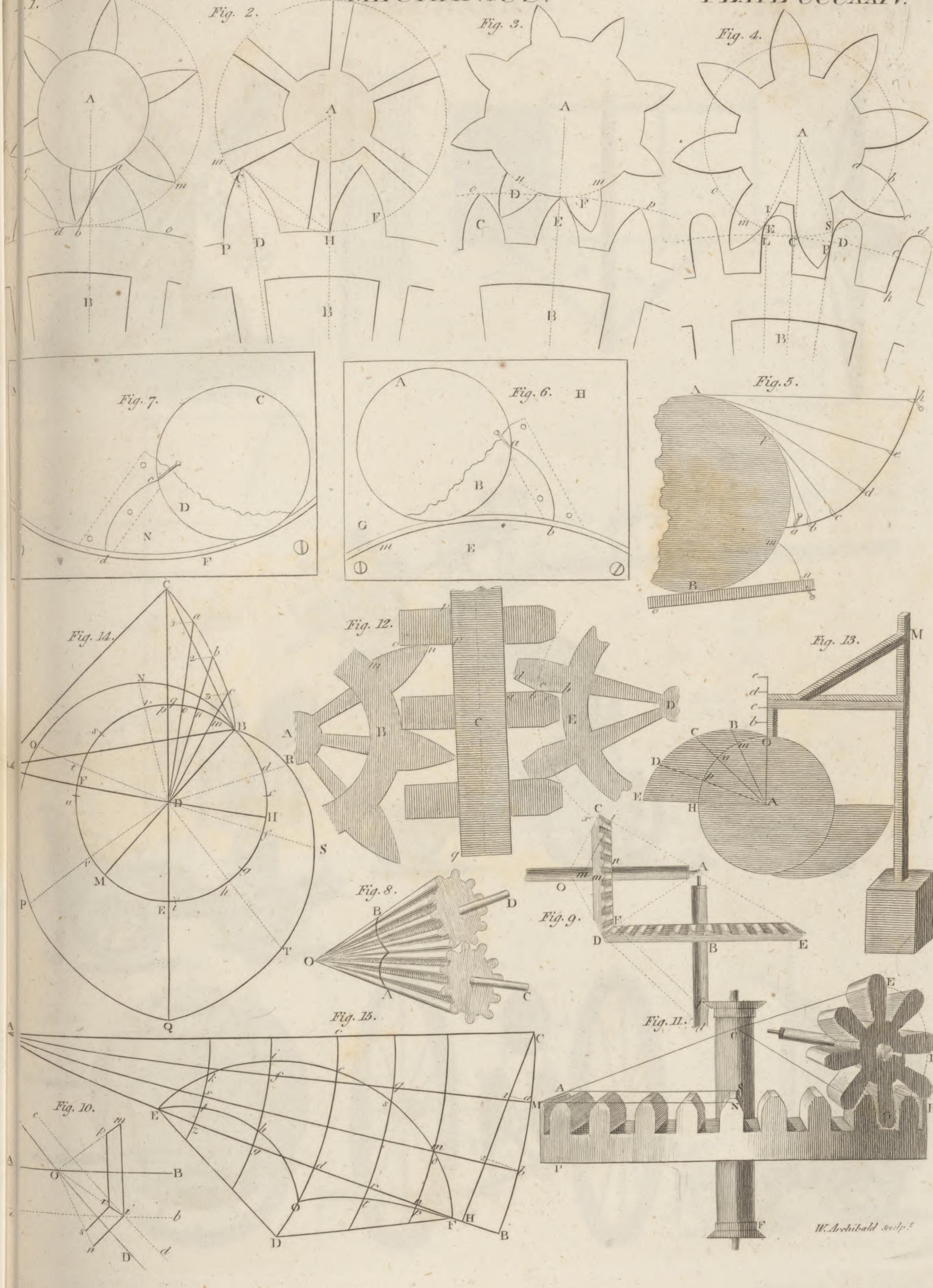
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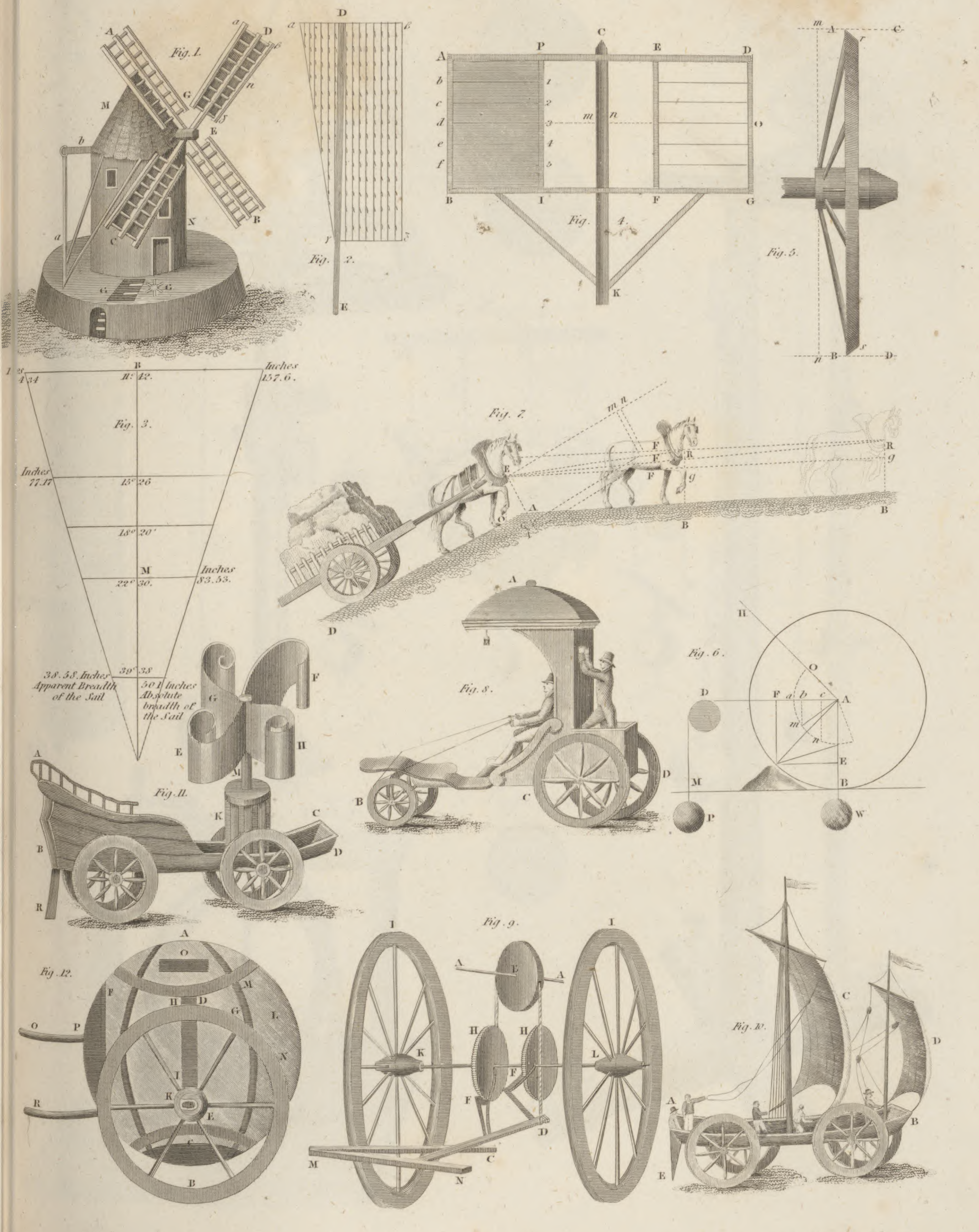

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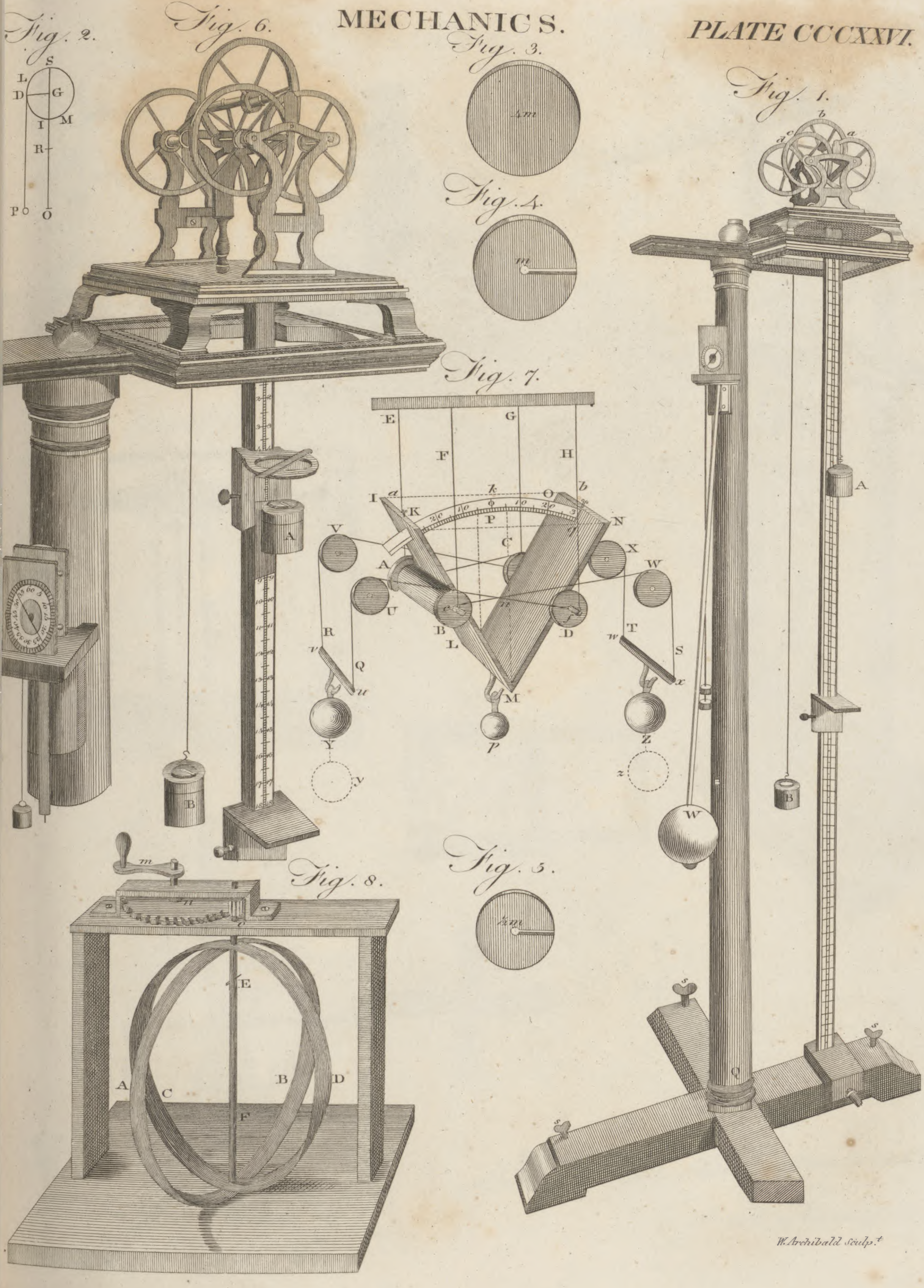
MECHANICS. PLATE CCCXXVI.



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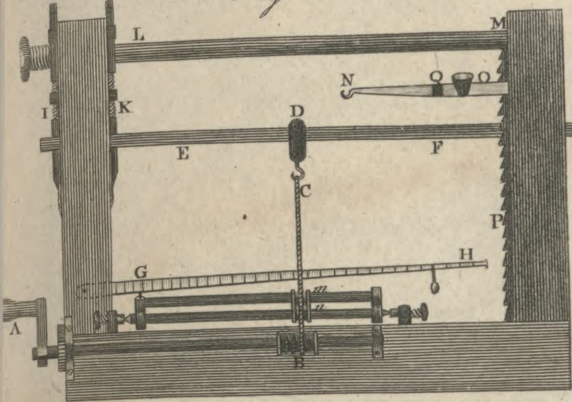

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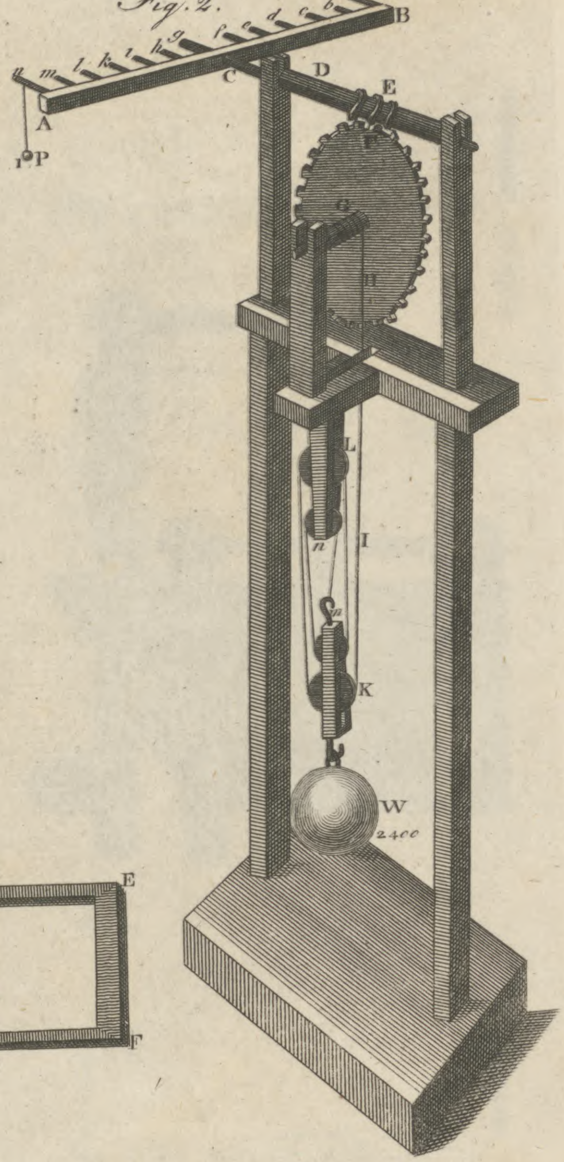

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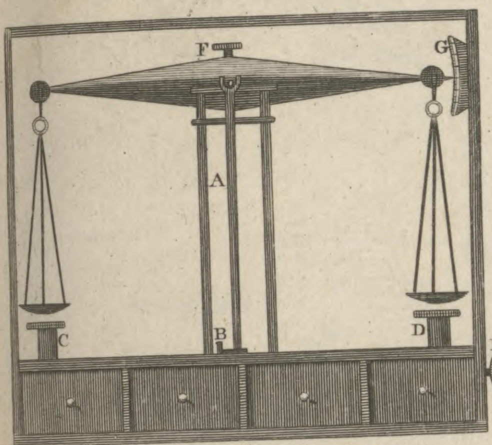

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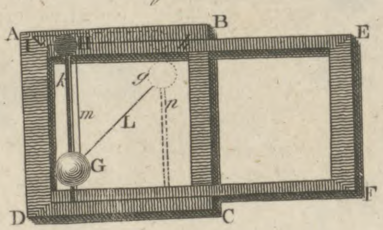

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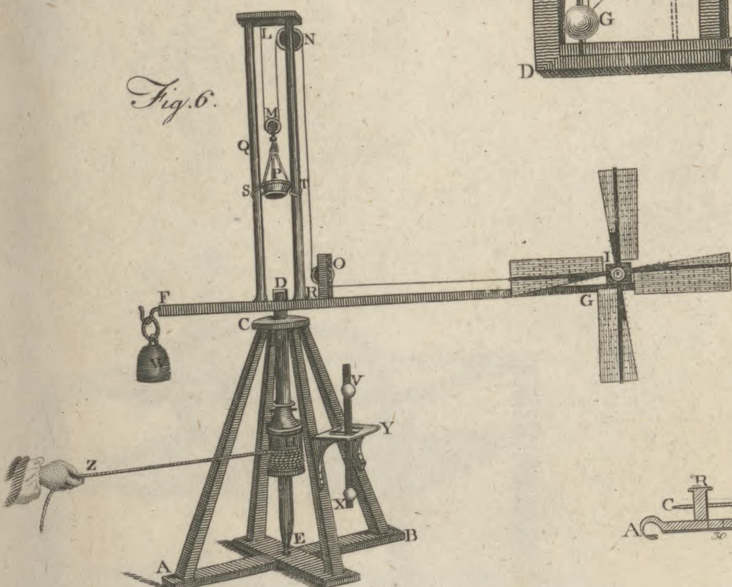

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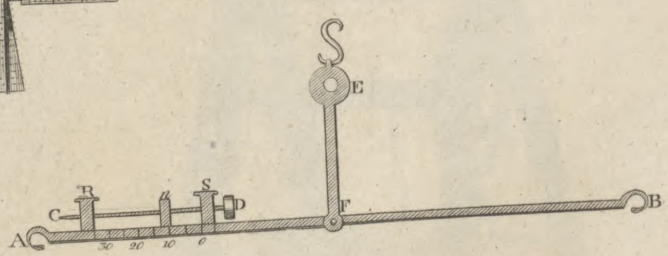

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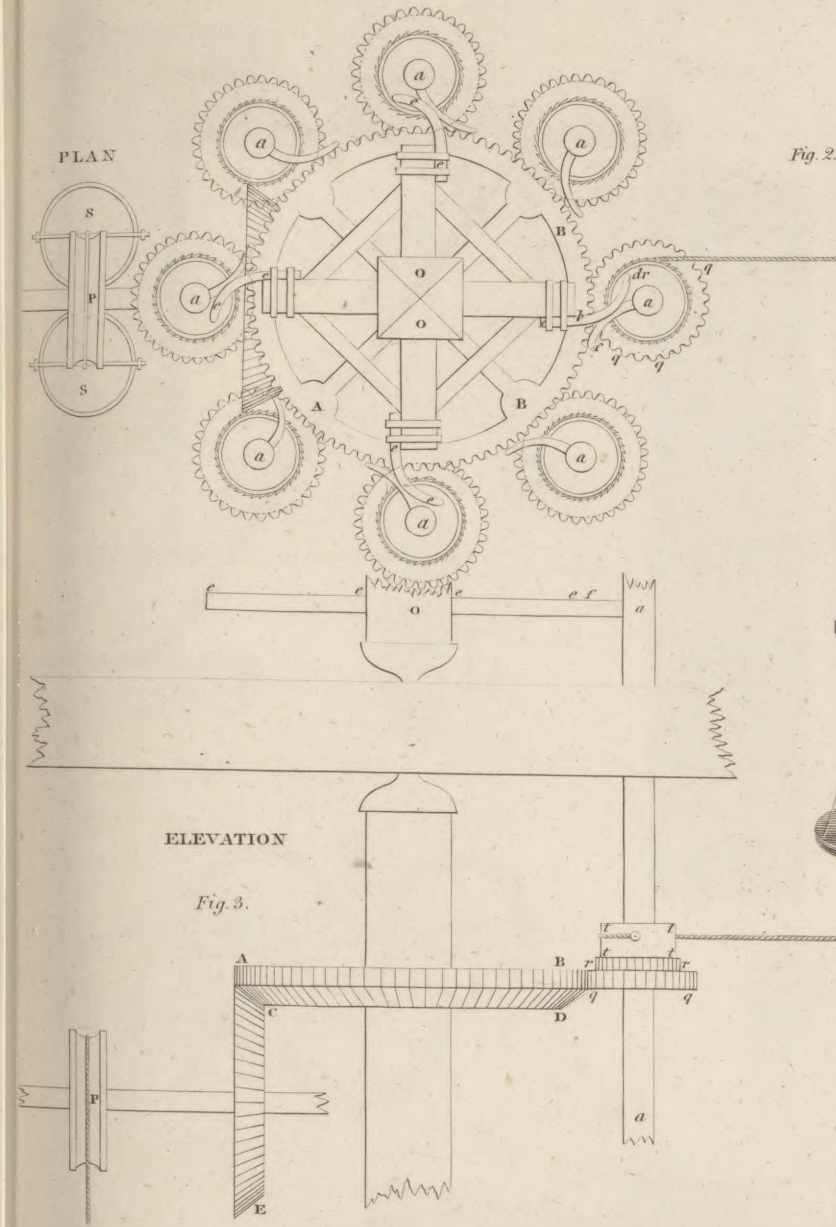

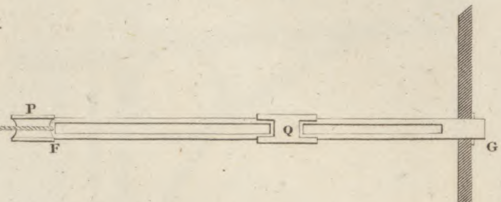

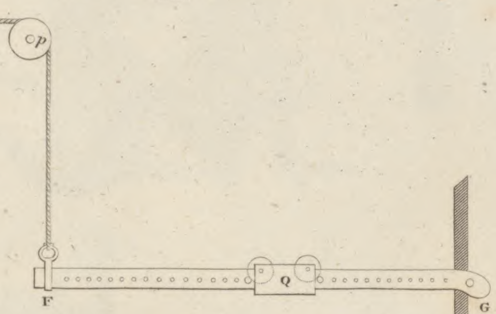

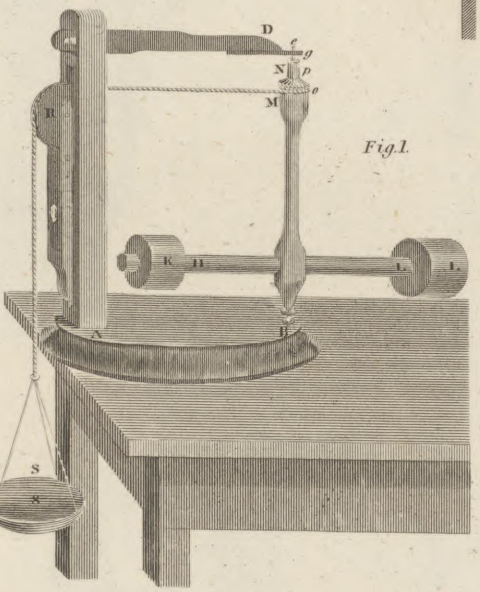

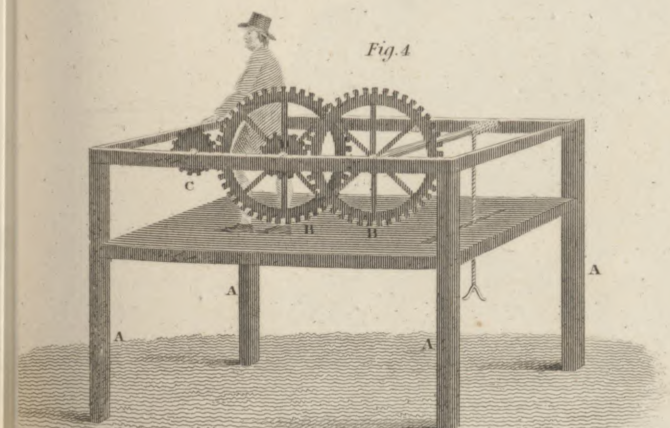

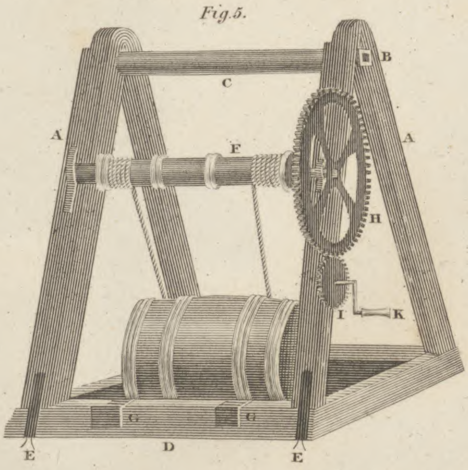

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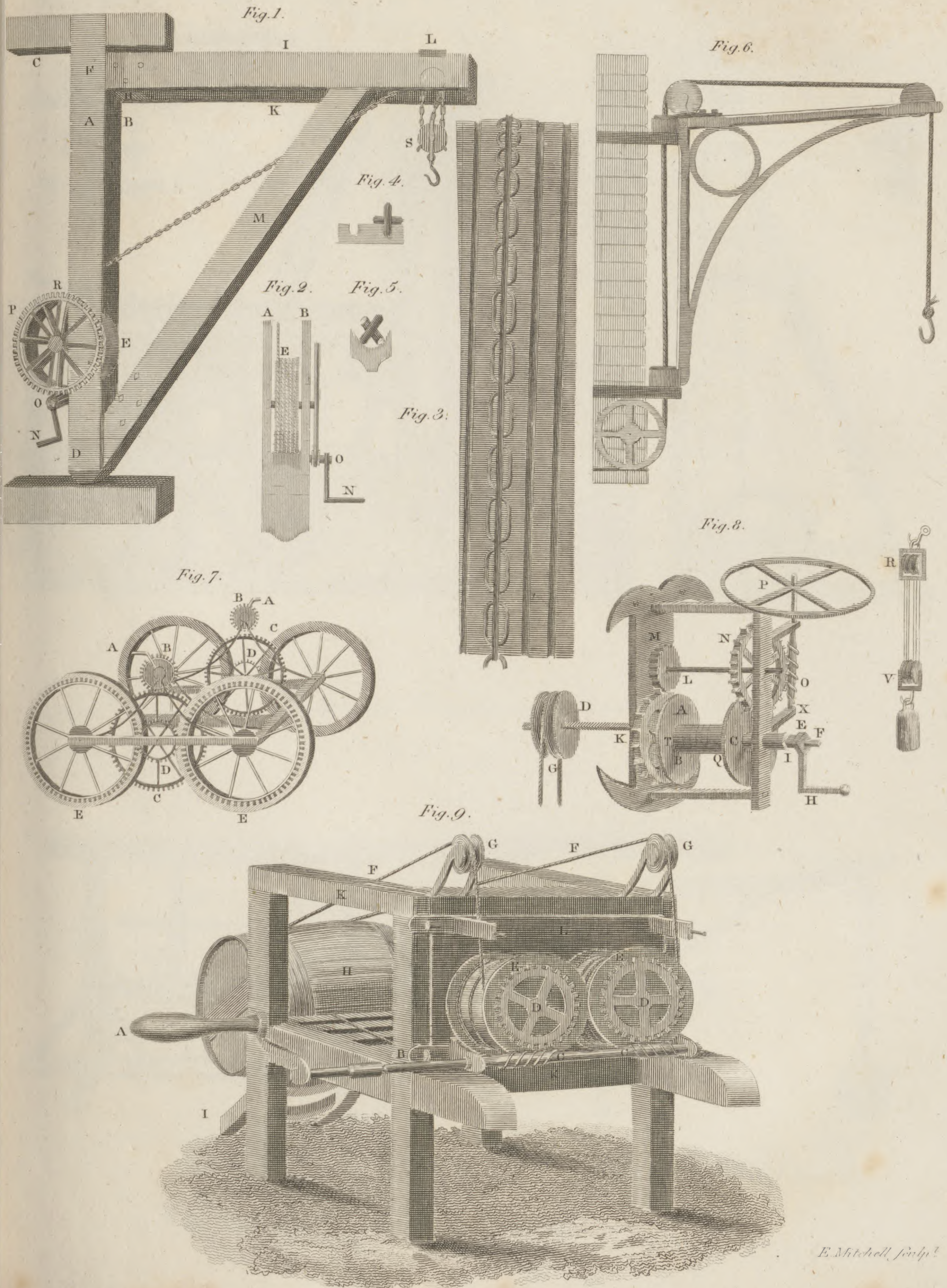
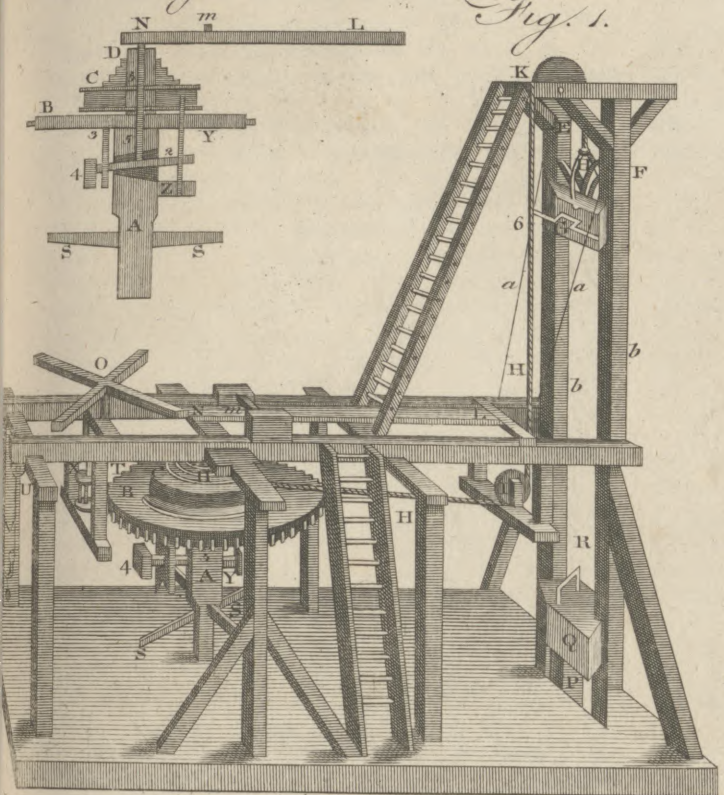


Fig. 1.
Fig. 2.
Fig. 3.
Fig. 4.
Fig. 5.
Fig. 6.
Fig. 7.
Fig. 8.
Fig. 9.
E. Mitchell sculp.

Vauloue's Pile Engine.

Fig. 2.

Fig. 1.

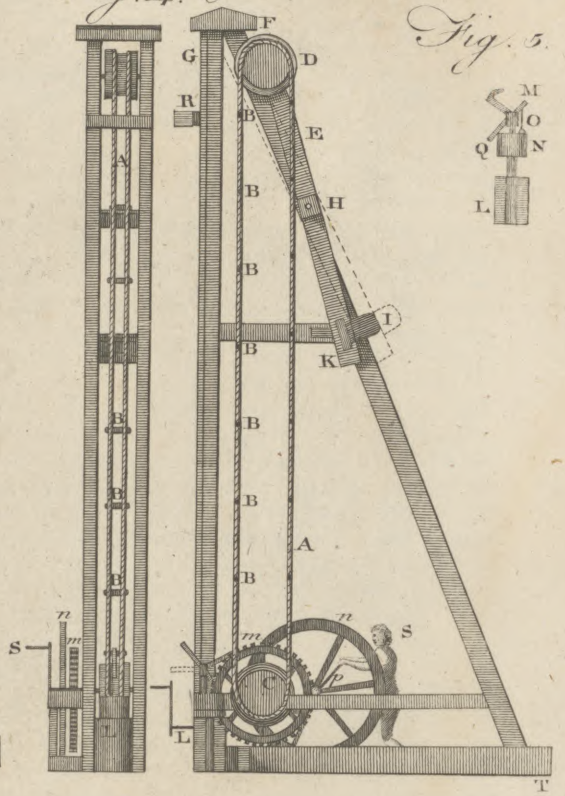


Bunce's Pile Engine.

Fig. 3.

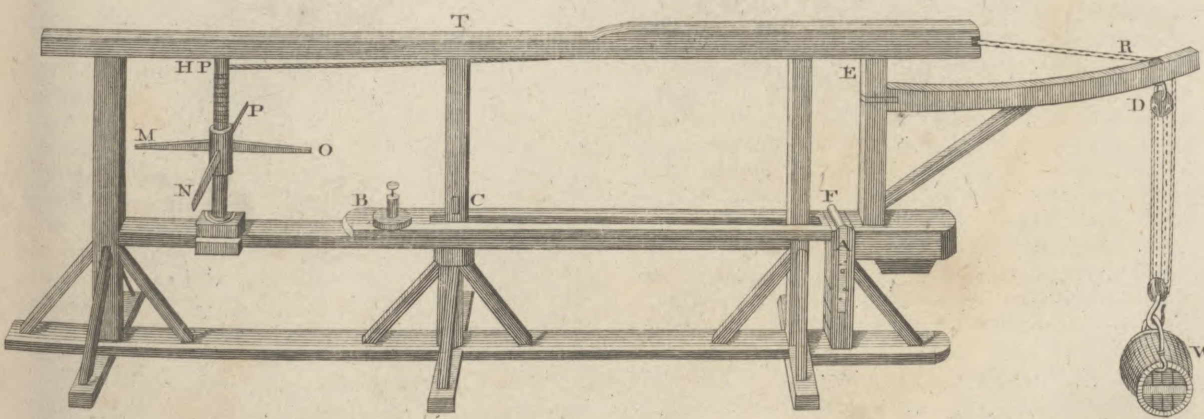
Fig. 4.

Fig. 5.



Andrew's Weighing Crane.

Fig. 6.



A. Bell Prin. Wal. Sculptor fecit.

Mechanism || Mecklenburg.

MECHANISM, either the construction or the machinery employed in any thing; as the mechanism of the barometer, of the microscope, &c.

MECHOACAN, a province of Mexico, or New Spain, in America, bounded on the north by Panuco and Guadalajara, on the east by Panuco and Mexico Proper, on the south by the Pacific ocean, and on the west by Guadalajara and the South Sea. It is about 200 miles in circumference, and its population in 1793 was 289,314. The soil is exceedingly fertile; and the climate so wholesome, that the Spaniards imagine it to be possessed of some peculiarly restorative quality; for which reason the sick and infirm flock to it from all quarters. The commodities are sulphur, indigo, sarsaparilla, sassafras, cacao, vanelloes, ambergris, hides, wool, cotton, silk, sugar, the root mechoacan or white jalap, and silver. This province formed an independent kingdom at the time Mexico was reduced by Cortez. The sovereign had long been the inveterate enemy of the Mexicans, and was considered next to the republic of Tlascala, as the most formidable barrier against the extension of the imperial frontier. However, he submitted to Cortez without striking a blow, being intimidated by the wonders he had performed with a handful of men; and thus Mechoacan became a province of the Spanish empire, and a valuable addition to Mexico. The country at that time was exceedingly populous, but the natives are now much thinned. The capital of the province, called *Mechoacan* by the natives, but *Valladolid* by the Spaniards, contained 17,093 inhabitants in 1793.

MECHOACAN, or *White Jalap*, in the materia medica, the root of an American species of convolvulus, brought from Mechoacan, a province of Mexico, in thin slices like jalap, but larger, and of a whitish colour. It was first introduced into Europe about the year 1524 as a purgative: but since jalap became known, mechoacan has been little employed.

MECKLENBURG, a duchy of Germany, containing those of Schwerin and Gustro, is bounded by Pomerania on the east, by part of the marquisate of Brandenburg and the duchy of Lunenburg on the south, the Baltic on the north, and Holstein and Saxe Lawenburg on the west. Their greatest length is about 135 miles, and greatest breadth upwards of 90. With respect to the soil, much cannot be said in favour of it, as it consists, in general, either of sand, or large and desolate heaths interspersed with moors, woods, fens, and lakes. It yields very little wheat, and not a great deal of oats, rye, and barley; but breeds a considerable number of sheep and cattle, has plenty of fish, with stone quarries, salt springs, alum, iron, and some copper. The principal rivers here are the Elde and Stor, which fall into the Elbe as it glides along the borders of this country to the south-west; the Reckenitz, which discharges itself into the Baltic; as do the Peene, the Warno, and the Stopenitz. This country has only one harbour on the Baltic, namely that of Rostock. In both duchies, exclusive of Rostock, are 45 great and small cities, with three convents, and a great number of manors and farms, belonging either to the duke, the nobility, or convents. The peasants are in a state of villenage; but the nobility enjoy very considerable privileges, The states are composed of the nobility and towns; and the diets, which are summoned annually, are held alternately at Sternberg and Malchin. The duchy of Schwerin appoints four provincial counsellors, and that of Gustro as many; who rank according to seniority, with the duke's actual privy counsellors, as their marshals do with the colonels. The lesser committee represents the whole body of the nobility and commons, by whom the members are chosen freely and without controul, and no edict relative to the whole country can be published without their consent, or in prejudice of their rights. The inhabitants of this country are mostly Lutherans, under their superintendants. There are also some Calvinists and Roman Catholics. Besides the grammar schools in the towns, there is an university at Rostock. The commodities of the duchy are corn, flax, hemp, hops, wax, honey, cattle, butter, cheese, wool, and wood, a part of which is exported; but hardly any manufactures.

Mecklenburg, Meconium.

Of the house of Mecklenburg, there are two lines still subsisting, viz. that of Schwerin and that of Strelitz. The latter commenced in Duke Adolphus Frederick II. younger brother of the duke of Schwerin, and grandfather of Adolphus Frederick IV. who entered on the government in 1752, and whose family received a great additional lustre by his Britannic majesty's taking his second sister for his consort, and by her own great merit and noble deportment in that high station. Besides the duchy of Strelitz, to this duke belong the principality of Ratzeburg, with the lordship of Stargard, the ancient commanderies of Miro and Nemero, and a yearly pension of 9000 dollars out of the Boitzenburg toll. The title assumed by both the dukes is *duke of Mecklenburg; prince of Wenden, Schwerin, and Ratzburg; count of Schwerin and the country of Rostock, and lord of Stargard*. By the agreement concluded at Wittstock in 1442, the elector of Brandenburg, on the extinction of the male line of the dukes of Mecklenburg, is entitled to their whole succession. The duke of Schwerin has two votes both in the diet of the empire and that of the circle. The matricular assessment for the duchies of Schwerin and Gustro is 40 horse and 67 foot, or 748 florins monthly, including what is paid by Sweden for Wismar, and the bailiwicks of Poll and Neukloster. To the chamber of Wetzlar, these two duchies pay each 243 rix-dollars, 43 kruitzers. For the government of Mecklenburg, the administration of justice, and the management of the revenue, there is the privy council of regency, the demesne chamber, the high and provincial court of justice, to which appeals lie in most causes, both from the consistory and the inferior civil courts, and which are common to both the dukes. As to the revenues, those of the Schwerin line must be very considerable, those arising from the demesne bailiwicks and regalia alone amounting to 300,000 rix-dollars per annum. There is a tax on land that produces no contemptible sum, and that called the *princess's tax* is fixed at 20,000 rix-dollars: besides all these, there are also free gifts. The whole revenues of the Strelitz branch are estimated at 120,000 rix-dollars. Each of these princes maintains a body of troops.

MECONIUM, the excrement contained in the intestines of an infant at its birth.

MEDALS.

Utility of them in History, &c.

MEDAL, denotes a piece of metal in the form of coin, such as was either current money among the ancients, or struck on any particular occasion, in order to preserve to posterity the portrait of some great person, or the memory of some illustrious action. Scaliger derives the word *medal* from the Arabic *methalia*; a sort of coin with a human head upon it. But the opinion of Vossius is generally received; viz. that it comes from *metallum*, "metal;" of which substance medals are commonly made.

Sect. I. *Utility of Medals in History, and various other Sciences.*

There are few studies of more importance to history than that of medals; the sole evidence we can have of the veracity of a historian being only such collateral documents as are evident to every body, and cannot be falsified. In modern times, these are found in public memoirs, instructions to ambassadors, and state papers of various kinds. Such memorials, however, are subject to various accidents, and besides commonly remain in the countries where they are first published, and cannot therefore give to the world at large that perfect and entire satisfaction which ought to be derived from genuine history; so that more durable and widely diffused monuments are still to be wished for. Such are public buildings, inscriptions, and statues; but these, excepting a few instances of the two last, are always confined to particular countries; so that medals alone remain as infallible documents of truth, capable of being diffused over all countries in the world, and of remaining through the latest ages.

1 Various writers on medals.

The first who showed the importance of medals in ascertaining the dates, and arranging the order of events, in ancient history, by means of medals, was Vaillant, in his History of the Kings of Syria, printed at Paris in 1681. By medals alone, he has been enabled to fix the chronology and important events of history, in the three most ancient kingdoms of the world, viz. Egypt, Syria, and Parthia. Many coins have been discovered since his time, which confirm the accounts he has given. He was followed in this method by Father Hardouin, though with less success. Hardouin's best work is his *Herodiades*, or Series of Successors to Herod king of Judæa. The same plan was pursued by Noris, in his learned Treatise on the Syro-Macedonian princes, and by Bayer in his History of Osrhoene, as well as by Froelich, in the work entitled *Annales Regum et Rerum Syriæ*, Vien. 1754, and another named Kevenhullers *Regum veterum Numismata Anecdota, auct. Perrara*, Vien. 1752, 4to, of which Froelich was properly the author. Corsini and Cary likewise published works of a similar nature; the former in 1744, *De Minnifari, aliorumque Armeniæ Regum, Nummis*, &c.; the latter in 1752, *Histoire des Rois de Thrace, et du Bosphore Cimmerien, eclaircie par les Medailles.*

Utility of them in History, &c.

2 Of the Greek coins.

The study of the Greek coins does not show the dates of events, though it illustrates the chronology of reigns. This defect, however, is abundantly supplied by those of Rome, which commonly mark the date of the prince's consulship, the year of his tribunician power; giving also, upon the reverse, the representation or poetical symbol of some grand event. The year of the tribunician power is sometimes imagined by antiquaries to be synonymous with that of the emperor's reign: but this is not the case; and Mr Pinkerton is at some pains to set them right in this respect. He finds fault with Julius Cæsar, when he assumed the sovereign authority, for taking upon him the title of Perpetual Dictator, as being synonymous with that of king or absolute governor, which the Romans abhorred. "He ought (says our author), under the disguise of some supreme magistrate of annual election, to have lulled the people with a dream, that they might terminate his power when they pleased; or that he himself would resign it, when the necessities of state which had required his temporary elevation had subsided." To this error Mr Pinkerton ascribes the assassination of the dictator, and commends the policy of Augustus, who, with far inferior abilities, continued in possession of the most absolute authority as long as he lived. The tribuneship was an office of annual election; and if put into the hands of any others than plebeians, must have been the supreme power of the state, as it belonged to that office to put a negative upon every public measure whatever. Augustus, being of senatorial rank, could not assume this office: but he invested himself with the tribunician power, which had the advantages of appearing to be only a temporary supremacy, though in truth it was continued during his whole lifetime. Towards the end of his reign, he frequently assumed his destined successor, Tiberius, for his colleague, though in the beginning he had enjoyed it alone. This, with his artifice of resigning his power every ten years, and reassuming it at the desire, as was pretended, of the senate, secured his sovereignty as long as he lived.—His example was followed by his successors; so that most of them have the inscription *Tribunicia Potestate* upon their medals, with the date affixed to it thus, *Tr. Pot.* VII. Yet though this date generally implies the year of the emperor's reign, it sometimes happens that the emperor, by special favour from a former prince, had been endowed with this title before he came to the throne, as being the successor to that prince, of which we have already given an instance in Tiberius. Besides the tribunician power, the emperors very frequently enjoyed that of the consuls; and the date of their consulship is frequently expressed in their coins.

3 Method used by Augustus to secure his power

The office of Pontifex Maximus was likewise assumed by the Roman emperors, in order to secure themselves in their authority; which, Mr Pinkerton observes, was one of the most efficacious artifices they could have fallen upon. "In the Greek heroic times (says lity of n in Hi- y, &c. (says he), king and priest were carefully united in one person; and when sovereigns arose in Denmark and Sweden, the same plan was followed, as appears from Snorro, and other writers. Nothing could lend more security to the person of the monarch than an office of supreme sanctity, which also confirmed his power by all the terrors of superstition. Even the Christian system was afterwards debased by a mock alliance with government; though it be clear from the whole New Testament, that such an alliance is subversive of its genuine institution, and the greatest of all its corruptions. But the Roman Catholic clergy, in the dark ages, were the authors of 'no church no king,' for their own interest; while the Roman emperors only sought to strengthen their power by the dark awe of superstition. The title of Pontifex Maximus was so important, that it was retained even by the Christian emperors till the time of Gratian. Its influence in the state was, indeed, prodigious. Cicero observes, that to this office were subject, temples, altars, penates, gods, houses, wealth, and fortune of the people.—That of augur is also borne by many emperors; and its authority was such, that by the law of the twelve tables no public business could be transacted without a declaration from the augur concerning its event.—The proconsular power was also given to Augustus and the other emperors. It conferred a direct authority over all the provinces, and implied the emperor to be chief proconsul, or governor of each, and of all. Another special power assigned to the emperors, but not occurring on coins, was the *Jus Relationis Tertiæ*, *Quartæ*, &c. or the right of making three or four motions in the senate on the same day, while the senators could only propose one.

Hence our author infers, that medals afford the most authentic documents of the Roman history, in particular, that could have been invented by man.—The histories of Nerva and Trajan are much better elucidated by medals than by authors; for the history of Suetonius ends with Domitian, and the *Historiæ Augustæ Scriptores* begin with Adrian: so that the reigns of the two emperors just mentioned are almost unknown; and Mr Pinkerton is surprised that none of the learned have attempted to supply the defect.—"Capitolinus (says he), in his life of Maximinus Junior is quite puzzled to know if Maximus and Pupienus were two emperors, or two names for the same. Had he happened on any of those coins which bear M. CL. PUPIENUS MAXIMUS AUG. he would have seen at once that Maximus was only another name for Pupienus."

4
e of me- ls in geo- aphy. Medals are useful in other sciences besides history. In geography, we find the situation of towns determined by their vicinity to some noted river, mountain, &c. Thus, ΜΑΓΝΗΤΩΝ ΣΙΠΥΛΟΥ shows that Magnesia was situated under Mount Sipylus. In like manner, it is shown from a medal, that Ephesus stood on the river Caÿster; and there is extant a medal, bearing an inscription, which signifies Alexandria on the Scamander; a name given to Troy by Alexander the Great. The reverse has upon it the famous Apollo

5
natural story. Smintheus of Homer. In natural history also, medals are useful chiefly from the coins struck on the celebration of the secular games, in which the figures of various animals are preserved; and thus it may very often be determined whether any animal be known to the ancients or not. On many of the Greek medals are several uncommon plants and animals. Thus, on most of the medals of Cyrene is the figure of the celebrated *Sylphium*; and on those of Tyre, the shell-fish from which the famous Tyrian purple was procured. By means of medals, also, the exact delineations of many noble edifices are preserved, though not even a vestige of their ruins be now existing; so that the uses of them to the architect are very considerable. To the connoisseur they are absolutely necessary; because by them alone he is enabled to ascribe ancient busts and statues to their proper persons, with multitudes of other points of knowledge which cannot be otherwise determined. The elucidations of obscure passages in ancient authors by means of medals are so numerous and well known, that it is needless to insist upon them.

Utility of them in History, &c.

6
In architecture.

7
In the fine arts.

Mr Addison has treated the connexion betwixt medals and poetry at considerable length; but Mr Pinkerton finds fault with him for preferring the Latin to the Greek poets. He observes also, that the knowledge of Greek medals is most necessary for a sculptor, and perhaps an architect: but an acquaintance with Latin ones is preferable for a poet, or perhaps a painter. The reason of this difference is, that the former generally have on the obverse the head of some king, god, or goddess, of exquisite relief and workmanship; but the reverse seldom affords much fancy of symbol in the early Greek coins; and in the imperial Greek coins, is chiefly impressed with the temples of their deities. To a person of poetical imagination, however, the Roman coins afford the greatest entertainment, from the fine personifications and symbols to be found on their reverses; of which our author gives the following instances:

8
Latin medals of use to a poet.

9
Personifications on Roman medals.

"HAPPINESS has sometimes the caduceus, or wand of Mercury, which Cicero, I. *Offic.* tells us was thought to procure every wish. She has, in a gold coin of Severus, heads of poppy, to express that our prime bliss lies in oblivion of misfortune.

"HOPE is represented as a sprightly girl, walking quickly, and looking straight forward. With her left hand she holds up her garments, that they may not impede the rapidity of her pace; while in her right hand she holds forth the bud of a flower; an emblem infinitely more fine than the trite one of an anchor, which is the symbol of Patience, and not of Hope. This personification, with some others, must have been very familiar to the ancients; for often in this, and in a few more instances, no name, as SPES AUG. or the like, is inserted in the legend.

"ABUNDANCE is imagined as a sedate matron, with a cornucopiæ in her hands, of which she scatters the fruits, and does not hold up her cornucopiæ and keep the contents to herself, as many modern poets and painters make her do.

"The emperor Titus, having cause to import a great supply of corn during a scarcity at Rome, that supply, or the ANNONA, is finely represented as a sedate lady, with a filled cornucopiæ in her left hand, which she holds upright, to indicate that she does not, however, mean to scatter it, as Abundance has a title to do, but to give it to Equity to deal out. This last particular is shown by her holding a little image of

 Equity,

Utility of them in History, &c.

Equity, known by her scales, and *hasta pura*, or pointless spear, in her right hand, over a basket filled with wheat. Behind the ANNONA is the prow of a ship decked with flowers, to imply that the corn was brought by sea (from Africa), and that the ships had had a prosperous voyage. The best poet in the world would not have given us a finer train of imagery; the best painter would have been puzzled to express so much matter in so small a compass.

"SECURITY stands leaning upon a pillar, indicative of her being free from all designs and pursuits; and the posture itself corresponds to her name. Horace, in describing the wise man, mentions his being *teres atque rotundus;* round and polished, against all the rules of chance: an idea seemingly derived from the column upon which this ideal lady reclines.

"The emblems of PIETY, MODESTY, and the like, are equally apposite and poetical.

"The happiness of the state is pictured by a ship sailing before a prosperous breeze: an image than which the superlative genius of Gray could find none more exquisite; and he has accordingly used it in his most capital production "The Bard," with due success.

"The different countries of the then known world are also delineated with great poetical imagery. It affords patriotic satisfaction in particular to a Briton, to see his native island often represented upon the earliest imperial coins, sitting on a globe, with a symbol of military power, the *labarum*, in her hand, and the ocean rolling under her feet. An emblem almost prophetic of the vast power which her dominion over the sea will always give her, provided she exerts her element of empire with due vigour and perseverance.

"Coins also present us with Achaia, Africa, Alamannia, Alexandria, Arabia, Armenia, Asia, Bithynia, Cappadocia, Dacia, Dardania, Egypt, Gallia, Hispania, Italia, Judæa, Macedon, Mauritania, Pannonia, Parthia, Phrygia, Sarmatia, Sicily, Scythia, Syria, and the rivers Danube, Nile, Rhine, Tiber. This personification of provinces seems to have arisen from the figures of provinces carried in triumphs; as the personification of our old poets sprung from the ideal persons actually represented in the mysterial plays.

"There is one colonial medal of rude execution of Augustus and Agrippa, which has a high claim to merit in displaying the ancient poetical imagery. It is inscribed IMP. and DIVI. F. and on the reverse, the conquest of Egypt is represented by the metaphor of a crocodile, an animal almost peculiar to that country, and at that period esteemed altogether so: which is chained to a palm tree, at once a native of the country, and symbolic of victory.

10.
Medals useful to a painter.

"As the reverses are so useful for knowledge of personification, symbols of countries and actions, and the like; so the portraits to be seen on old coins are no less important to a painter; the high merit of a great number of them, in every character, justly entitling them to be regarded as the best studies in the world. Not to mention, that, to an historic painter, the science of ancient medals is absolutely necessary, that he may delineate his personages with the features they really bore while in existence. This can only be attained in this way, or from statues and busts; any one of which will cost as much as hundreds of medals; and indeed a collection of such is only attainable by princes.

The same things which render the study of medals important to a painter, do still more so to a sculptor; and, in this particular, the study of the Greek coins is remarkably useful. The skill of the Greeks in the art of sculpture has always been admired throughout the world; and on their coins the heads of several deities are represented in the most exquisite *alto relievo.* Our author, therefore, thinks it strange, that the Grecian coins should have hitherto been so little attended to by men of learning and taste. They may have been looked upon, he supposes, as belonging only to the province of the antiquary; but he assures us, that the Greek medals will afford satisfaction to the persons who value them only as pieces of workmanship. In most respects, they greatly excel those of Rome even in its best times; which our author supposes to have been from the days of Augustus to Adrian. "In the days of Adrian, in particular (says he), the Roman mint seems to have been the very seat of art and genius; witness the vast number of exquisite personifications, engraven with equal workmanship, which swarm on the medals of that prince. Yet from his time down to Posthumus, coins of admirable workmanship are to be found. Those of the Faustinas and Lucilla deserve particular mention. There is one, and not an uncommon one, of the latter, in great brass, which yields to nothing of the kind. The reverse is a Venus with the name around her. The portrait of the obverse seems to spring from the field of the coin; it looks and breathes, nay talks, if you trust your eyes. The coins of Tarsus are extremely remarkable for a kind of perspective in the figures, as Froelich observes. On others are found triumphal arches, temples, fountains, aqueducts, amphitheatres, circi, hippodromes, palaces, basilicas, columns and obelisks, baths, sea-ports, pharoses, and the like. These furnish much pleasure and instruction to the architect, and serve to form his taste to the ancient manner; that manner which unites perfect simplicity with sublimity and grace; that manner which every age admires, in proportion as it has genius to imitate."

Entertainment from studying them.

11.
To a sculptor.

SECT. II. *Entertainment arising from the Study of Medals.*

BESIDES the purposes which the study of medals answers in the useful arts, a great variety of sources of entertainment are to be found in it. Mr Pinkerton observes, that the most barbarous nations are more pleased with the rudest efforts of art, than with the most admirable works of nature; and that in proportion as the powers of the mind are large and various, such are also the pleasures which it receives from those superlative productions of art, which can only be the offspring of vast genius. Hence works of art are agreeable both to the enlightened and to the ignorant. The chief amusement, therefore, which attends the study of medals, originates from the strength and spirit, the finish and beauty, which the engraver has displayed in the execution of them. It besides gives a kind of personal acquaintance with the persons of whom they are the representations. Portraits have always been ertain- t from ying em. been highly entertaining to mankind; and our author is of opinion, that the love of them gave rise both to painting and sculpture. They are nowhere to be found so ancient, so numerous, and so well preserved as in medals. Amusement is also derived even from the representations of ideal heads and persons; nay, even from the minutest symbols. Thus the Greek coins of cities present us with heads of deities of exquisite workmanship, apparently copied from statues or paintings; so that we may even guess at the works of Apelles and Praxiteles from some of the Greek medals. Their reverses afford still greater variety; there being scarce an object either in art or nature which is not represented upon some of them: and to the satisfaction arising from a view of these, we may likewise add that of beholding, in a lively manner, the dresses, manners and customs, religious and civil ceremonies, of the ancients: so that from medals we may obtain an interesting history of manners; which, though very lately cultivated, may perhaps afford the most useful and entertaining of all the provinces of history.

12 rence ixt a alist anti- y.

There is a very considerable difference betwixt the study of medals and that of a mere antiquary. The latter frequently seems to take delight in coins merely in proportion to their rust and deformity; so that it is often a recommendation of some of their pieces, that neither portrait, reverse, nor legend, can be discovered; at least in such manner as can be intelligibly explained. "The delight of the antiquarist (says Mr Pinkerton), may be called a depraved appetite of the mind, which feeds on trash, and fills itself with emptiness. It is perhaps a mere childish curiosity mingled with caprice and hypochondricism. Against this character the ridicule of Severus is particularly shot, but with little effect; for our antiquists exceed in visions and nonsense. I say *antiquists;* for the name of antiquary is sacred. By *antiquary,* in foreign countries, is implied a man who illustrates their ancient laws, manners, poetry; but especially their ancient history. There, men of the most elevated minds are antiquaries; as Muratori, Leibnitz, Montesquieu, Du Bos. Here men of talents will not stoop, forsooth, to studies the most important to their country, but leave its antiquities to chance. Every thing is important but our history; and we are profound in every ancient matter that is superficial; and superficial in what is profound. Even England cannot boast of one general historian, but trusts to the inaccuracy of Rapin, and the ignorant neatness of Hume. It is therefore no wonder that the study of antiquity is here ridiculous, though most important in other countries; none requiring greater talents, learning, or industry. But the historic antiquary has the pleasure of benefiting society, and enlightening whole nations, while the medallic has only an innocent amusement. This amusement, considered merely as rising from antiquarian objects, has not been explained, though felt by most people, and more by the learned. It seems analogical with that which we derive from an extensive prospect: for as the mind delights to expand itself into distant places, so also into distant times. We connect ourselves with these times, and feel as it were a double existence. The passions are singularly affected by minute circumstances, though mute to generalities; and the relicks of antiquity impress us more than its general history."

Sect. III. *History of Medals.*

The study of medals is not of very ancient date: None of the classic writers give any account of collections of them; though indeed many little particulars are passed without notice by them. In the times of the Greeks, a collection of such coins as then existed must have been but little regarded, as consisting only of those struck by the numerous little states which at that time used the Greek characters and language. Hence they would have had an air of domestic coinage, and no atttention would have been paid to them, however exquisite their workmanship might have been. The little intercourse at that time carried on betwixt the different provinces also, greatly impeded any communication of knowledge to those who wrote histories; so that it is no wonder to find any small collections that might then have existed altogether unnoticed by them.

Almost as soon as any communication was opened between the Greeks and Romans, the latter treated the arts of the Greeks with all due respect and applause. Their coins were imitated by the Romans, and preserved in cabinets by the senators among their choicest treasures. Suetonius informs us, that on solemn occasions Augustus was accustomed to present his friends with medals of foreign states and princes, along with other valuable testimonies of his friendship. In a more advanced period of the Roman empire, however, individuals would undoubtedly form collections of coins peculiar to their own state; for Dr Stukeley, in his Medallic History of Carausius, informs us, that a complete series of silver coins was lately found in Britain, containing all the emperors down to Carausius inclusively. From Banduri we also know, that certain Greek coins were specially preserved by the Romans; and it appears from their code, that ancient gold and silver coins were made use of instead of gems; to which distinction those of Sicily were particularly entitled. From the decline of the Roman empire till towards the end of the fifth century, almost all branches of literature were involved in darkness, and the medallic science among the rest. While the Christian dominion of Constantinople lasted, indeed, almost all the arts and sciences may be said to have been kept within its own boundaries; though the Arabs and eastern nations had some arts and sciences of their own: but after the destruction of the imperial city by the Turks, the Greeks were once more compelled to become fathers to the European science. Even before this time, indeed, some vestiges of a revival of literature had appeared in Italy; and so intimate and necessary a connexion (says Mr Pinkerton), has now the study of medals with that of ancient erudition, that on the earliest appearance of a revival of the latter, the former was also disclosed."

13 Greek coins imitated by the Romans.

14 Collectors of medals.

The first among the moderns who began to study the medallic science was Petrarch. Being desired by the emperor Charles IV. to compose a book containing the lives of eminent men, and to place him in the list, he replied, that he would do so whenever the emperor's life and conduct deserved it. In consequence of this conversation, he afterwards sent the emperor a collection of gold and silver coins bearing the representations

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sentations of eminent men, with an address suitable to his former declaration. A collection of coins was made in the next age by Alphonso king of Arragon; but though this monarch collected all that could be found throughout Italy, we know that there could not have been very many, as the whole were contained in an ivory cabinet, and carried always about with him. A very considerable collection was made by Anthony Cardinal St Mark, nephew to Eugene IV. who ascended the pontifical chair in 1431; and soon after the grand museum at Florence was begun by Cosmo de Medici, where a collection of ancient coins and medals had a place among other curiosities. Corvinus king of Hungary about the same time formed a noble collection of coins along with ancient manuscripts and other valuable relicks of antiquity.

Mr Pinkerton considers Agnolo Poliziano, more commonly known by the name of *Angelus Politianus*, as the first writer who adduced medals as vouchers of ancient orthography and customs. He cites different coins of the Medicean collection in his Miscellanea written about the year 1490. By means of a cabinet of medals collected by Maximilian I. emperor of Germany, Joannes Huttichius was enabled to publish a book of the lives of the emperors, enriched with their portraits, delineated from ancient coins. It is generally supposed that this book, which appeared in 1525, was the first work of the kind; but Labbé, in his *Bibliotheca Nummaria*, mentions another named *Illustrium Imagines*, by one Andreas Fulvius, printed in 1517, in which most of the portraits seem to be from medals. About the year 1512 also, Guillaume Bude, a French author, had written his treatise *De Asse*, though it was not printed till many years afterwards. M. Grollier, treasurer of the French armies in Italy, during part of the 16th century, had a great collection of coins of different kinds of metals. After his death, his brass medals were sent to Provence, and were about to be sent into Italy; when the king of France, having got information of the transaction, gave orders to stop them, and purchase the whole at a very high price for his own cabinet of antiquities. M. Grollier had an assortment of gold and silver as well as of brass medals; the cabinet in which they were contained fell two centuries afterwards into the hands of M. l'Abbe de Bothelin; and was known to have been that of Grollier from some slips of paper, on which was his usual inscription for his books, *Joannis Grollierii, et amicorum.*

15 Number of cabinets.

Cotemporary with Grollier was Guillaume de Choul, who was likewise a man of rank and fortune. He had a good collection of medals, and published many in his Treatise on the Religion of the ancient Romans in 1557. In the Low Countries we know, from the letters of Erasmus, that the study of medals was begun about the beginning of the 16th century. About the middle of that century, Hubertzus Goltzius, a printer and engraver, travelled over most countries in Europe searching for coins and medals, in order to publish books concerning them. From one of these works it appears, that there were then in the Low Countries 200 cabinets of medals; 175 in Germany, upwards of 380 in Italy, and 200 in France. It is probable, however, that there are now four times as many in these countries, besides 500 in Britain; but we are not to imagine that all these were grand collections, for of such there are not above a dozen even in Italy: most of those just mentioned were of the class named *caskets* of medals, containing from 100 to 1000 or 2000.

16 Number of coins found in Britain.

There are few countries, Italy excepted, in which a greater number of coins have been found than in Britain; though we are by no means well acquainted with the time when the study of them commenced. Mr Pinkerton suspects that Camden was one of the first, if not the very first British author, who produced medals in his works, and who must have had a small collection. Speed's Chronicle, published in the 17th century, was illustrated with coins from Sir Robert Cotton's cabinet. Gorlæus's collection was purchased by Henry prince of Wales, brother to Charles I. to whom he left it at his death. According to Joseph Scaliger, it consisted of 30,000 coins and medals. A collection of 5500 coins was purchased by Archbishop Laud for 600l. and given to the Bodleian library. Thomas earl of Arundel, earl-marshal of England, well known from the Arundelian tables and other antiquities which he imported from Greece and Italy into Britain, had a rich cabinet of medals collected by Daniel Nisum. The dukes of Buckingham and Hamilton, Sir William Paston, Sir Thomas Fanshaw of Ware-Park, Sir Thomas Hanmer, Ralph Sheldon, Esq. Mr Selden, &c. are enumerated by Evelyn as collectors of medals. Charles I. as well as his historian the earl of Clarendon, were also collectors. The king had a very fine cabinet; which, however, was dissipated and lost during the civil commotions. Oliver Cromwell had a small collection; and the cabinet of Charles II. is mentioned by Vaillant in the preface to his treatise entitled "*Nummi in Coloniis*," &c. This branch of magnificence has not been much attended to by succeeding British monarchs; though his present majesty has a very good collection of ancient gold coins.

17 British cabinets.

A great number of fine cabinets have been formed in Britain since the time of Evelyn. About the year 1720, Haym makes mention of those of the duke of Devonshire, the earls of Pembroke and Winchelsea, Sir Hans Sloane, Sir Andrew Fontaine, Mr Sadler, Mr Abdy, Mr Wren, Mr Chicheley, and Mr Kemp. At present there are many remarkable collections; but that of the late Dr William Hunter is deservedly esteemed the most remarkable in Europe, excepting that of the late French king. Is was not only formed at a great expence, but with much care and ability; many foreign medals offered to it having been rejected (A). The other remarkable collections are those of the duke of Devonshire, the earl of Pembroke, Earl Fitzwilliam, formerly the marquis of Rockingham's, the honourable Horace Walpole, the reverend Mr Crachrode, the reverend Mr Southgate, Mr Townley, Mr

R. P.

(A) This collection, as well as the rest of Dr Hunter's Museum, is now in the possession of the university of Glasgow, to which it was bequeathed by the doctor's will.

Of what constructed. R. P. Knight, Mr Edward Knight, Mr Tyson, Mr Barker, Mr Brown, and several others. The British museum and universities in England have also collections; as well as the Advocates library, the Antiquarian Society, and the universities in Scotland.

Sect. IV. *Materials of which Medals are constructed.*

Ancient gold coins. Medals are formed of gold, silver, and the various modifications of copper. The gold usually made use of in coinage is about the fineness of 22 carats; and as the art of purifying this metal was very much unknown in former times, the most ancient medals are for this reason much more impure than the modern coins. Gold is never found in its native state above 22 carats fine; and the very ancient medals are much under that standard. Many of them are composed of a mixture of gold and silver, called by the ancients *electrum*. The gold medals were made of much finer metal after Philip of Macedon became possessed of the gold mines of Philippi in Thrace, and the medals of his son Alexander the Great are equally fine; as well as those of some other princes of that age. Those of the Egyptian Ptolemies are of the fineness of 23 carats three grains, with only one grain of alloy. The Roman coins are very pure even from the earliest times; the art of refining gold being well known before any was coined at Rome. Some authors are of opinion, that the Roman coins begin to fall short of their purity after the time of Titus; but Mr Pinkerton denies that any thing of this kind takes place till the time of the emperor Severus; and even then only in a very few instances. Most of the Roman gold was brought from Dalmatia and Dacia, where that metal is still to be met with. A very remarkable circumstance is observed in the eastern part of Hungary, which belonged to the ancient Dacia. It germinates in the vines of Tokay, and is found in their stems; as it is elsewhere in the straw of corn.

Metal called electrum. Pliny informs us, and indeed it is generally known, that gold and silver are found mixed together in the earth. Where the silver amounted to one-fifth part of the gold, the metal was called *electrum*; but sometimes the quantity of silver was added artificially. The gold was in those days as well as at present refined by means of mercury; and the ancient artists had certainly attained to great perfection in this branch of metallurgy; as Bodin tells us, that the goldsmiths of Paris upon melting one of Vespasian's gold coins found only $\frac{1}{788}$ part of alloy.

Ancient silver. Most of the ancient silver, particularly that of Greece, is less pure than that of succeeding times; even the Roman silver is rather inferior to the present standard, and that from the very beginning; but in the time of Severus, the silver appears very bad, and continues so until the time of Dioclesian. Many writers upon this subject have mistaken the *denarii ærei*, "coins of brass washed with silver," for silver currency. Silver coins are extremely scarce from the time of Claudius Gothicus to that of Dioclesian, or from the year 270 to 284: in which short space no fewer than eight emperors reigned. Silver at that time was found mostly in Spain; and the commerce with that country was disturbed by the usurpers who arose in Gaul; and such were the troubles of the times, that not only the silver but also the gold coins of those eight emperors, are extremely scarce. There is still, however, some silver extant of these eight emperors; and it is certain, that copper washed was never used as silver currency, but was entirely a distinct coinage. Occasional depravations of silver had taken place long before; as Pliny tells us, that Mark Antony mixed iron with his silver denarii; and Mr Pinkerton informs us, that he had seen a denarius of Antony, which was attracted by a magnet.

21 Ancient brass. The ancient brass coins consist of two kinds: the red or Cyprian, which indeed is no other than copper; and the common yellow brass. Our author observes, that in the Roman coinage brass was of double the value of copper, and he is of opinion, that it was the same among the Greeks; and the latter is the metal most commonly made use of in the Greek coinage. The Roman sestertii was always of brass: the middling-sized kind are partly copper and partly brass; the former being double the value of the latter, which are the *ases*.

22 Mixed metals. Mr Pinkerton next proceeds to give an account of the mixed metals used among the Romans. In Britain all kinds of coins made of mixed metal are without hesitation alleged to be forgeries; although it is certain that the variety of mixed metals used in coinage was very considerable. The most valuable mixture was that of gold and silver, already mentioned, named *electrum*; the silver commonly amounting to one-fifth part of the gold made use of, or perhaps more. Of this mixture are many of the early coins of Lydia, and some other Asiatic states; also those of the kings of the Bosphorus Cimmerius, during the imperial ages of Rome. Next to the electrum were the coins of Corinthian brass: but Mr Pinkerton informs us, that

23 Corinthian brass. not a single coin was ever struck of this metal by the ancients; it having been constantly employed only in the fabrication of vases or toys. It was in use at any rate only for a very short time; being altogether unknown in the days of Pliny the Elder. Our author therefore ridicules those who pretend not only to find out imperial coins of this metal, but to discover three kinds of it; viz. one in which the gold predominates, another in which the silver prevails, and a third where the brass is most conspicuous. He gives Æneas Vico, one of the most ancient writers on medals, as the author of this idea; but whose opinions were confuted by one Savot, a writer in the 17th century. Vico mentions a coin of this kind struck under Augustus, another of Livia, and a third of Claudius. The mistake, he is of opinion, arose from the circumstance of the first propagator not being able to account for the various mixtures and modifications of brass observable in ancient coins of the large size; and which in so common a metal appear very odd to the moderns. Besides the authority of Pliny and other antiquaries of a more modern date, who all declare that they never saw a single medal of Corinthian brass, or of that metal mixed with silver and gold, our author adduces another evidence which he looks upon to be superior to either; viz. that those who have given into this supposition, imagine, that the large pieces called *sestertii*, and others called *dupondiarii*, worth about twopence or a penny, are said to have been composed of this precious metal. It is unreasonable to think, that any proportion of gold

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gold or silver could have been made use of in these. The coins said to have been struck upon Corinthian brass are only done upon a modification of common brass; of which we know, that in proportion to the quantity of zinc made use of in conjunction with the copper, the metal assumes a variety of hues. On the authority of Pliny he informs us, that the coins mistaken for Corinthian brass were no other than prince's metal.

24 Egyptian silver coins.

The Egyptian silver coins struck under the Roman emperors are at first of tolerably pure silver; but afterwards degenerate into a mixture of copper and tin with a little silver. They are very thick, but many of them are elegantly struck, with uncommon reverses. There are likewise three sets of brass coins belonging to this country from the earliest times of the Roman emperors there. Some of these are of bell-metal or pot-metal; and after the time of Gallienus and Valerian, the coinage of brass with a small addition of silver, becomes authorised by the state; the coins struck upon it, being called *denarii ærei*. Those of lead or copper plated with silver have been fabricated by Roman forgers. Some coins of lead, however, have been met with of undoubted antiquity: and an ancient writer informs us, that tin money was coined by Dionysius; but none has been found. The lead coins of Tigranes king of Armenia, mentioned as genuine by Jobert, are accounted forgeries by Mr Pinkerton and other modern medallists. Plautus, however, makes mention of leaden coins, and several of them have been found; but our author looks upon them to have been chiefly essay pices, struck in order to let the artist judge of the progress of the die. Others are the plated kind already mentioned, fabricated by ancient forgers, but having the plating worn off. A great number of leaden coins are mentioned by Fricorini in a work entitled *Piombi Antichi*, in which he supposes them to have served as tickets for guests; and coins of the same kind are also mentioned by Passeri. In the work entitled *Notitia Imperii Romani*, there is mention of coins made of leather, but none of them have ever been found.

Sect. V. *Of Ancient Money.*

In considering the different sizes, values, &c. of the Greek and Roman coins, our author treats of the medals as money; a knowledge of which, he says, is essentially necessary to every reader of the classics; insomuch that it may almost dispute the preference with the studies of ancient geography and chronology. Notwithstanding all that has been written upon the subject, however, our author is of opinion, that the science is still in its infancy, in as far as it relates to the real money of the ancients. "The ideal (says he), which is indeed the most important province of discussion, has been pretty clearly ascertained; and we are almost as well acquainted with the Attic *mna* or *mina*, and the perplexing progress of the Roman *sestertia*, as with our own *pounds*. But with the actual coin of the ancients the case is different; and the ignorance even of the learned in this point is wonderful."

25 Knowledge of ancient money imperfect.

Our author now goes on, with great asperity of language, to particularize the ignorant manner in which modern authors have treated the subject of medals. "Arbuthnot and Clarke (says he), are, if possible, more ignorant of medals than Budæus the very first. The latter professes his love of medals, but quotes a consular coin with the head of Cicero; and looks upon one of the 30 pieces of silver, the reward of the treachery of Judas, and which was said to be preserved among some relicks at Paris, to be worthy of reference and commemoration. Arbuthnot, if we may judge from his book, had never seen any ancient coins; and Clarke, it is well known, was quite ignorant of them. The latter, with all his labour, seems even to have known nothing of the theoretic part of the real ancient money. Indeed Dr Mead's catalogue seems to have been almost the only *book* on medals which had undergone his perusal. On the other hand, the ignorance of medallists on this score is no less profound. To this day they look upon the *didrachms* of Ægina, so celebrated in antiquity, as *tridrachms* of Ægium; and upon the early obolus as a brass coin. In the Roman class the large brass is esteemed the *as*, while it shall be proved that it is the *sestertius*, and worth four *ases*. The *denarius* is reckoned at ten ases even in the imperial times; whereas it only went at that rate for the first 90 years after the coinage of silver at Rome. The denarius æreus is taken for silver currency; with other mistakes, which evince that medallists are as ignorant of the theory, as the others are of the practice."

26 Money coined in the east

In his account of the ancient Greek money, Mr Pinkerton observes, that the light of science, like that of the sun, has proceeded from east to west. "It is most probable (says he), that the first invention of money arose like the other arts and sciences; and spread from thence into the western parts of the world. In its first shape it appeared as mere pieces of metal without any stated form or impression; in lieu of which, it was regulated by weight. Even down to the Saxon government in England, large sums were regulated by weight; and in our own times every single piece is weighed in gold; though with regard to silver this nicety is not minded, nor indeed does it seem practicable. Among the ancients, whose commercial transactions were less important and extensive than those of the moderns, silver was weighed as well as gold; nay even brass in some cases. 27 Its first rude state

28 Greek money.

In Greece, large sums were determined by *mnæ* or *minæ*; and the most capital sums by *talents*. In every country the mina is supposed to have contained 100 drachmæ, or small silver coins, of that country, and the talent 60 minæ. The mina is supposed to be a pound weight of the country to which it belonged. The Attic pound, according to Dr Arbuthnot, contained 16 ounces, equal to our avoirdupois pound: but Mr Pinkerton looks upon this as a very absurd opinion, and accuses the doctor of having adopted it merely that he may explain a passage in Livy. He is of opinion, that the Attic pound is very nearly the same with the pound Troy. The mina of Athens had at first 73 drachms; but by Solon it was fixed at 100. The ancient drachm weighed the same which it does at present in medical weight, viz. the eighth part of an ounce. The mina or pound of 12 ounces had consequently 96 of these drachms; but four of them were given to the round sum to supply defects in the alloy; "and indeed (says our author), in consequence of a common

common practice in all ages and in all countries, of giving some addition to a large weight. Thus the pound in weight had but 96 drachmæ in fact, while the pound in tale had 100; as the Roman libra in weight had but 84 denarii, in tale 108; and as our pound in tale, by an inverse progress, is not a third of our pound in common weight.

Of the ancient talents

Notwithstanding the very severe criticism on Dr Arbuthnot just mentioned, however, we find our author adopting his account of the *talents* used in coinage in several countries. Thus, according to the doctor,

The Syrian talent had	-	15 Attic minæ
Ptolemaic	-	20
Antiochian	-	60
Eubœan	- -	60
Babylonian	- -	70
Larger Attic	-	80
Tyrian	- -	80
Egyptian	- -	80
Æginean	-	100
Rhodian	- -	100

Notwithstanding the concession made here by Mr Pinkerton to the doctor, he tells us, that he very much questions this list of talents, and that many ancient writers are little to be relied upon. "Writers on this subject confess, that the numbers in all ancient manuscripts are the parts most subject to error, as being almost always contracted. They ought to allow that the authors themselves must often be liable to wrong information.

"Herodotus mentions, that King Darius ordered gold to be paid into his treasury by the Euboic talent, and silver by the Babylonian. The Euboic is esteemed the same with that called afterwards the Attic; and as we estimate gold by carats, so it is natural to suppose, that the most precious metal would be regulated by the most minute weight. But I confess I take the Babylonic talent to be the same with that of Ægina. Mr Raper has proved the first coins of Macedon to be upon the standard of Ægina. Now the early Persian coins are upon that very scale, the largest tetradrachms weighing from 430 to 440 grains. Hence it follows, that the Persian silver coins were of the Æginean standard; and the payment was certainly to be made according to the standard of the money. The larger Attic talent was of 80 lesser minæ; because the larger Attic mina was of 16 ounces. The Alexandrian talent, according to Festus, consisted of 12,000 denarii, being the same with that used by the Egyptian kings in their coins; and is shown by Mr Raper to have been the same with the talent of Ægina. Perhaps the whole of the ancient coins of Asia, Africa, Greece, Magna Græcia, and Sicily, are reducible to three talents or standards. 1. That of Ægina, used in most of the more ancient silver coinages; as would seem in even the later of Egypt, Carthage, Cyrene, &c. 2. The Attic (being the Asiatic gold standard, afterwards used by Phidon king of Argos in estimating gold, and called Euboic from Eubœa, one of the quarters of the city of Argos), used in Athens and the greater part of the world as the standard both of gold and silver. 3. The Doric or Sicilian talent of 24 nummi, each worth an obolus and a half; whence the talent is estimated at six Attic drachms or three daries. These weights continued to be the standard of money after it began to be distinguished by impression; nay, to the fall of Greece and prevalence of the Roman empire."

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30 Coinage originates in Lydia.

Coinage, according to Herodotus, was first invented by the Lydians, from whom the Greeks quickly received it. The former could not have received it from the Persians, whose empire did not begin till 570 B. C. though our author supposes that it might have proceeded from the Syrians, who carried on commerce in very ancient times. The most ancient Greek coins of silver have an indented mark upon one side, and a tortoise upon the other; and those of the greatest antiquity have no letters upon them. Those of later date have ΑΙΓΙ marked upon them, which medallists interpret of Ægium in Achaia; being led into that supposition by the tortoise, which they look upon as a sure mark of the Peloponnesus. But though our author agrees that the tortoise was so, he thinks that they are otherwise very far wrong in their conclusions. Ægium in Achaia was a place of no consequence till the times of Aratus and the Achæan league; but there are 11 of these coins in Dr Hunter's cabinet, which show that they must have been struck in times of the most remote antiquity, and that the place where they were struck was rich and flourishing at the time. The coins we speak of are not common; but those which have the name ΑΙΓΕΙΩΝ at full length, and which may perhaps belong to Ægium in Achaia, are extremely scarce; insomuch that in all Dr Hunter's vast collection there are not above one or two. They are likewise constructed upon a scale quite different from all other Grecian money; being of 8, 13, 15$\frac{1}{7}$, 90, and about 186 grains. The Grecian drachma at an average is 66 grains; and Mr Pinkerton thinks it would have been strange if pieces had been struck of eight-tenths of an obolus, of an obolus and a half, or of a drachma and a half. Ægium being originally an obscure village, could not be the first which coined money: so that Mr Pinkerton supposes the name ΑΙΓΙ to have stood for Ægialus, the ancient name of Sicyon, a wealthy and powerful city; or rather Ægina, the mint of which was much celebrated, and perhaps the most ancient in Greece.

31 Most ancient Greek coins described.

Other arguments in favour of these coins being derived from Ægina, are drawn from their weight as well as their workmanship, which are quite different from those bearing the name of Ægium at full length. The coinage of Ægina is known to have been different from that of the rest of Greece; insomuch that its drachma was worth 10 Attic oboli, while the Attic drachma was valued only at six. Hence the drachmas of Ægina were named by the Greeks παχειαν, or *thick*; a name very applicable to the coins in question. From these observations, our author is of opinion, that we may even distinguish the precise weight of the ancient coins of Ægina. According to the exact proportion, the drachma of this place should weigh exactly 100 grains; and one of them very much rubbed weighed above 90. The others of larger size, which seem to be didrachms of Ægina, weigh from 181 to 194 grains; but the latter being the only one he could meet with in good preservation, it was impossible to form any just medium. Even in those best preserved, he

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he thinks that 10 grains may be allowed for a waste of the metal in so long a time, as 2400 years, which would bring the drachma of Ægina near its proper standard. The obolus of Ægina was in proportion to its drachma of six oboli. It is the piece of $15\frac{1}{2}$ grains, and 13 when very much rubbed. The hemiobolon is that of eight, but when rubbed it falls short of this weight.

32 The drachma the most general denomination.

The general denomination of the Greek money is the drachma, or eighth part of an ounce; which to this day is retained in the medical weights, the Grecian coins receiving the names they bore from their weights: though in some instances the weights received their appellations from the coins. The silver drachma, according to Mr Pinkerton, was about ninepence sterling; and he finds fault with those who make the drachma and denarius both equal to one another, the latter being no more than eightpence. The didrachm of silver, according to the same calculation, was worth 18d.; but the *tridrachm* occurs very rarely: and Mr Pinkerton is even of opinion, that medallists give this name to the didrachm of Ægina. The largest of all the Grecian coins is the tetradrachm, which on the Æginean standard is worth five shillings; but in those of the other states only four. There are, however, many subdivisions in the silver drachma; the highest being the tetraobolion or coin of four oboli; being in proportion to the drachma as our groat to a sixpence, weighing about 44 grains, and being in value about sixpence. The hemidrachm or triobolion comes next in value, weighing about 33 grains, and worth fourpence halfpenny. The silver diobolion, or third of the drachma, weighs about 22 grains, and is worth threepence. The obolus of silver weighs about 11 grains, and is worth only three halfpence. There is likewise a hemiobolion in silver, or half the obolus, of five grains and a half, value three farthings: and another called *tetraobolion dichalcos* or quarter obolus, which is the most minute coin yet met with; and by reason of its extreme smallness, weighing only two grains and a quarter, is now very scarce: but there is one in the cabinet of Dr Hunter, and some more have been lately brought from Athens by Mr Stuart. Some of them are likewise met with at Tarentum. It would appear, however, that there were some still smaller, and of value only three-fourths of a farthing. None of these have been met with; and the smallness of the size renders it improbable that any will ever be met with; as the peasants, who commonly discover coins, would probably either not observe them at all, or, if they did, would neglect them as things of no value.

33 Different names of Greek coins.

Many different names have been imposed on the coins belonging to the different states of Greece: thus Κορη, *the maiden*, was a name often applied to the tetradrachm, and which would seem to apply to those of Athens; though there are coins of other cities with the head of Proserpine, and the word Κορη, to which it would appear more applicable in our author's opinion. Χελωνε, *the shell*, was the name of another coin, from its type. A Sicilian coin was named Δημαρετιον, from Gelon's wife. A tetradrachm was named Κραπαταγους, and had eight ευθειας or hemidrachms. The Τροισηνιον, so called from its country Troizene, had Pallas on one side and a trident on the reverse. The hemiobolion was the πελανος of Lacedæmon; and the κολλυβος is supposed to have been equal to the Roman sestertius or quarter drachma. The *cystophori* were coins with the mystic chest or hamper of Bacchus upon them, out of which a serpent rises; and are much celebrated in antiquity. We are told by Livy, that Marcus Acilius, in his triumph over Antiochus and the Ætolians, carried off 248,000 of them; Cneius Manlius Vulso in that over Gallo-Græcia had 250,000; and Lucius Emilius Regillus, in his naval triumph over the fleets of Antiochus, had 131,300. Cicero likewise mentions his being possessed of a vast sum in them. The most probable opinion concerning them seems to be, that they are all silver tetradrachms; such as belong to the cities of Apamea and Laodicea in Phrygia; Pergamus in Mysia; Sardis and Tralles in Lydia; and Ephesus; but it is a mistake to ascribe any to Crete. Mr Pinkerton thinks it absurd to imagine that Crete, a small island, should strike such vast numbers of coins; though Cicero mentions his being in possession of an immense treasure in them at the time he was governor of Asia Minor. "It is most likely (says Mr Pinkerton), that his wealth should be in the coin of the country to which he belonged. But what had these triumphs of Cicero's government to do with Cretan money? But indeed the coins themselves, as above noticed, establish the fact."

34 Coins of Cyzicus.

Another set of coins famous in antiquity were those of Cyzicus in Mysia, which were of gold; but they are now almost entirely vanished by being recoined in other forms. The Αρυανδικον νομισμα, or *money of Aryandes*, who was made governor of Egypt by Cambyses, is made mention of by Hesychius; but none of them, as far as is known, have reached our times. They must have been marked with Persian characters, if with any. The coin of Queen *Philistis* is mentioned by the same writer, and many of these pieces are still extant; but we know not where this queen reigned, nor does there seem to be any method of finding it out. Mr Pinkerton inclines to believe, that she presided over Sicily; and as a confirmation of that supposition, mentions some inscriptions of ΒΑΣΙΛΙΣΣΑΣ ΦΙΛΙΣΤΙΔΟΣ on the *Gradini* of the theatre at Syracuse; but which appear not older than the Roman times. Some authors are of opinion, that she reigned in Cossara or Malta; which our author thinks much more improbable.

35 Athenian coins.

The most particular attention with regard to the names and standard of coins is due to those of Athens; and it is most remarkable, that most of them which have reached us are of a very late period, with the names of magistrates inscribed upon them. Some of these bear the name of Mithridates; and few are older than the era of that prince; who, it is well known, took the city of Athens in his war with the Romans. I suspect (says Mr Pinkerton), that no Athenian coins of silver are posterior to Sylla's infamous destruction of that city; an event the more remarkable, as Sallust tells us, that Sylla was learned in Greek. Indeed Caligula, Nero, and most of the pests of society, have been learned men, in spite of a noted axiom of Ovid,

Sed ingenuas didicisse feliciter artes
Emollit mores, nec sinit esse feros.

It is still more remarkable, that the fabric of Athenian

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36 Greek copper money. The copper money of the Greeks is next in antiquity to the silver. Mr Pinkerton is of opinion, that it was not used at Athens till the 26th year of the Peloponnesian war; about 404 years before Christ, and 300 after silver was first coined there. The first copper coins were those of Gelo of Syracuse, about 490 B. C.

37 Of the chalcos. The chalcos of brass, of which eight went to the silver obolus, seems to have been the first kind of Greek coin. At first it was looked upon as of so little consequence, that it became proverbial; and to say that a thing was not worth a *chalcos*, was equivalent to saying that it was worth nothing. As the Greeks became poor, however, even this diminutive coin was subdivided into two, four, nay eight λεπτα or small coins; but our author censures very severely those who have given an account of those divisions. "Pollux, and Suidas copying from him (says he), tell us, that there were seven lepta to one chalcos; a number the most unlikely that can be, from its indivisibility and incapacity of proportion.

"Pollux lived in the time of Commodus, so was too late to be of the smallest authority: Suidas is four or five centuries later, and out of the question. Pliny tells us, that there were ten chalci to the obolus; Diodorus and Cleopatra that there were six; Isidorus says there were four: and if such writers differ about the larger denomination, we may well imagine that the smaller equally varied in different states; an idea supported by these undeniable witnesses, the coins which remain. Most of the Greek copper coin which has reached our times consists of chalci; the lepta being so small as to be much more liable to be lost." In Dr Hunter's cabinet, however, there are several of the dilepta of Athens: and from being stamped with the representation of two owls, seem to be the same with the silver diobolus: "a circumstance (says Mr Pinkerton), of itself sufficient to confute Pollux; for a dilepton can form no part of seven; a number indeed which never appeared in any coinage of the same metals, and is contradictory to common sense. It may be observed, that the whole brass coins of Athens published by Dr Combe are reducible to four sizes, which may be the *lepton*, *dilepton*, *tetralepton* or *hemichalcos*, and *chalcos*. The first is not above the size of one of King James I.'s farthing tokens; the last about that of our common farthing." The lepta was also called κερμα, as being change for the poor. The κιδαβος, perhaps so called from the figure of a wolf upon it, was the coin of a particular state, and if of brass must have weighed three chalci. The other names of the copper coins of Greece are but little known. Lycurgus ordered iron money to be coined at Sparta; but so perishable is this metal, that none of that kind of money has reached our times.

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38 Lepton, dilepton, &c.

After the conquest of Greece by the Romans, most of the coins of that country diminished very much in their value, the gold coinage being totally discontinued: though some of the barbarous kings who used the Greek character were permitted to coin gold, but they used the Roman model; and the standard used by the few cities in Asia who spoke the Greek language in the times of the emperors is entirely unknown. Copper seems to have been the only metal coined at that time by the Greeks themselves; and that upon the Roman standard, then universal through the empire, that there might be no impediment to the circulation of currency. They retained, however, some of their own terms, using them along with those of the Romans. The *assarion* or *assarium* of Rome, the name of the diminished *as*, being 16 to the drachma or denarius, the obolus was so much diminished in value as to be struck in brass not much larger than the old chalcos, and valued at between two or three assaria; which was indeed its ancient rate as to the drachma. This appears from the copper coins of Chios, which have their names marked upon them. The brass obolus, at first equal in size to the Roman sestertius or large brass, lessens by degrees to about the size of a silver drachma. From the badness of the imperial coinage in Greece also, it appears that brass was very scarce in that country, as well as in all the cities using the Greek characters; being found mostly in the western countries of the Roman empire. The time of this declension in size of the Greek coins is by Mr Pinkerton supposed to have been from Augustus down to Gallienus. He is of opinion, however, that the copper obolus, at first above the size of large brass, was used in Greece about the time of its first subjection to Rome; and that the lepta ceasing, the chalci came in their room, with the dichalcus and the hemiobolion of brass.

39 Era of the declension of the Greek coinage.

40 Gold coins of Greece. With respect to the gold coins of the Greeks, Mr Pinkerton is of opinion that none of that metal was coined before the time of Philip of Macedon, as none have reached our times prior to the reign of that monarch. From a passage in Thucydides our author concludes, that in the beginning of the Peloponnesian war the Athenians had no gold coin. Mentioning the treasure in the Acropolis or citadel of Athens, at the commencement of that war, the historian mentions silver coin, and gold and silver in bullion; and had any of the gold been in coin, he would certainly have mentioned it. Philip began his reign about 68 years after the beginning of the Peloponnesian war; and we can scarce suppose that any city would have preceded

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ceded the elegant and wealthy Athens in the coining of gold.

41 Gold coined early in Sicily.

Notwithstanding, however, this deficiency of gold coin among the Greeks, it is certain that the coinage of gold had taken place in Sicily long before; as we have gold coins of Gelo about 491 B. C. of Hiero I. 478, and of Dionysius I. in 404, all using the Greek characters; though not to be ranked among the gold coins of Greece, as Philip caused his to be. Gold coins of Syracuse even appear of the third class of antiquity, or with an indented square, and a small figure in one of its segments. Gold coins are used in the cities of Brettium, Tarentum, and throughout Magna Græcia; also in Panticapæa in Thrace, and likewise Cosa in that country; but not in Tuscany, as is commonly believed, though Neumann proves that they were struck by Brutus, and are unquestionably as ancient as the Greek coins. The Thebans and Athenians probably coined the first gold after Philip had set them the example, and when they were attempting to resist the projects of that enterprising monarch. The Ætolians probably coined their gold during the time of their greatest power, about a century after Philip, and when they were combating the power of Aratus and the Achæan league. "There is (says Mr Pinkerton) but one ἡμιχρυσος of Thebes, much worn, in Dr Hunter's cabinet, and weighing but 59 grains; and perhaps not above two or three χρυσοι or gold didrachms of Athens in the world; one of which is also in the collection of Dr Hunter, and weighs 132½ grains. It appears to be more modern than the reign of Philip. That monarch having got possession of the mines of Philippi in Thrace, improved them so much, that they produced him annually above a thousand talents of gold, or 2,880,000l. of our money. From this gold the first coins named from the monarch, *Philippi*, were struck. They were marked with his portrait; and for many ages after were so numerous, that they were common in the Roman empire; whence the name *Philippi* became at length common to gold, silver, and at last even brass coins of their size. Even in the time of Philip gold was very scarce in Greece: but after the Phocians had plundered the temple of Delphos, this precious metal, which had been valued as gems, and consecrated only to the decoration of the temples of the gods, began to be known among the Greeks. The comparative value of gold and silver, however, seem to have been at that time very different from what they are now. Herodotus values gold at 13 times its weight in silver; Plato in his Hipparchus at 12; and even the low value of 10 to 1 seems to have been the stated value in Greece, though in Rome the plenty of silver from the Spanish mines made the value of gold to be much higher; and there is no reason to think that it was ever valued in that city at less than 12 times its weight in silver. The *Philippus* χρυσος, gold piece, or *stater*, is a didrachm, and is the most common of all the ancient coins. Mr Pinkerton is of opinion that it went for 20 silver drachms on its first appearance; but in latter times for 25 Greek drachmæ or Roman denarii. There are proofs of the Philippi being didrachms, both from the writings of ancient authors and from numbers of the coins themselves, which remain to this day; and that the χρυσος, or principal gold coin of Greece, was of the same weight, is also evident from ancient writings. It was anciently worth about 15s. but valuing gold now at the medium price of 4l. per ounce, it is worth about 20s. The ἡμιχρυσος, or half the former coin, scarcely occurs of the coinage of Philip and Alexander, though it does of Hiero I. of Syracuse and of King Pyrrhus. It passed for ten silver drachmas, and was valued only at 7s. 6d. though now worth 10s. There was another division of this kind worth about 5s. There were besides some lesser divisions of gold coins, which could not be worth above two drachmas. These were coined in Cyrene; and there were besides several old gold coins of Asia Minor, the value of which is now unknown. Our author supposes that they were coined not with relation to their weight as parts of the drachma, but merely to make them correspond with so many silver pieces as was necessary. There are also larger coins than the χρυσος, the διχρυσος of Alexander and Lysimachus being double its value. Some others are met with of Lysimachus, Antiochus III. and some of the Egyptian monarchs, weighing four times the χρυσος, and now worth about 4l. sterling. Some weigh even more; but this our author supposes owing to a difference in the purity of the gold.

42 Roman Money.

In Rome, as well as in Greece, the money was at first estimated by weight; and the first metal coined by that people was copper, silver being long unknown in Rome; nor is it certainly known that any silver has ever been found in the Italian mines. In Rome the first valuation of money was by the *libra gravis æris*, or pound of heavy brass: and in the progress of their conquests, the little silver and gold that came in their way was regulated by the same standard, as appears from the story of Brennus. The weights made use of were the same with those which continue to this day. The pound consisted of 12 ounces of 458 grains each; but the pound by which the money was weighed appears to have consisted only of 420 grains to the ounce, or to have contained in all 5040 grains. This became the standard of copper; and when silver came to be coined, seven denarii went to the ounce as eight drachms did in Greece. Gold was regulated by the *scriptulum* or *scrupulum*, the third part of a denarius, and by the larger weights just mentioned. The number 10 was at first used by the Romans in counting their money; but finding afterwards that a smaller number was more convenient, they divided it into quarters; and as the quarter of 10 is 2½, they for this reason bestowed upon it the name of *sestertius* or "half the third;" to express that it was two of any weights, measures, &c. and half a third; whence the sestertius came at last to be the grand estimate of Roman money. The *as* being at first the largest, and indeed the only Roman coin, the word *sestertius* means *sestertius as*, or "two ases and a half." On the first coining of silver, the denarius of ten ases was struck in the most common and convenient denary division of money, or that by tens; the sestertius being of course two ases and a half. But the denarius being afterwards estimated at 16 ases, the name sestertius was still applied to a quarter of the denarius, though it now contained four ases. The term *sestertius* was applied to all sums not exceeding 1000 sestertii, or 8l. 6s. 8d.; but for greater sums the mode of the sestertius was likewise altered, though not to exclude the former. Very large sums

43 Of the Roman pound.

44 Sestertii, as, &c.

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sums of money were estimated by the hundred weight of brass; for the Romans were at first unacquainted with the talent. The hundred weight, by way of eminence, was distinguished by the name of *pondus*, and *sestertium pondus* became a phrase for two hundred weight and a half. Mr Pinkerton is of opinion, that we may value the *as libralis* of ancient Rome at about eightpence English. Estimating the *as* therefore at a pound weight, the *sestertium pondus* was equal to 1000 *sestertii*, or 8l. 6s. 8d.; and by coincidence which our author supposes to have been the effect of design, as soon as the silver coinage appeared, the *sestertium centum denariorum* was always equal to 8l. 6s. 8d. also. The word *sestertium* itself, however, seems to have been unknown prior to the coinage of silver money at Rome: the *pondera gravis æris* being sufficient before that time for all the purposes of a state in which money was so scarce. But however this may be, the *pondus* or hundred weight of brass was precisely worth 100 denarii, or a pound of silver. As the great sestertium was always valued at 1000 of the smaller, or 8l. 6s. 8d. we never find one sestertium mentioned in authors, but two, three, or more; ten thousand of them being equal to 83,333l. 6s. 8d.

Whence the Romans derived their coins.

The states from which the Romans may be supposed first to have derived their coinage, were the Etruscans and the Greek colonies in Magna Græcia and Sicily. Joseph Scaliger, Gronovius, &c. contend that it was from the Sicilians that the Romans first derived their knowledge of money; but Mr Pinkerton argues that it was from the Etruscans. In confirmation of his opinion, he appeals to the state of the Roman territories in the time of Servius Tullius, who is looked upon to have been the first who coined money at Rome. At that time the whole Roman dominion did not extend beyond ten miles round the city; and was entirely surrounded by the Etruscan and Latin states; Cumæ being the next Greek colony to it that was of any consequence, and which was in the neighbourhood of Naples, at about the distance of 150 miles. Our author asks, Is it reasonable to think that the Romans received the use of money from the Etruscans and Latins who were their neighbours, or from the Greeks, who were at a distance, and at that time, as far as appears from their history, absolutely unknown to them? "If this argument (adds he), is strong with regard to the nearest Grecian colonies, what must it be with respect to Sicily, an island 300 miles distant from Rome, where it was not known, at that time, if a boat went by land or water?" Arguments, however, for this opinion have been derived from the similarity betwixt the Sicilian and Roman coins; which Mr Pinkerton now proceeds to examine. The Greek pound in Sicily was called λιτρα, and consisted, like the Roman, of 12 ουγκιαι, or ounces; and Mr Pinkerton grants that the Roman *libra* was derived from the Greek λιτρα, but denies that the *as*, or libra, a coin, was from Sicilian model. The Sicilians had indeed a coin named λιτρα; but it was of silver, and of equal value to the Æginean standard, ten of which went to the Sicilian δεκαλιτρα. He differs from Gronovius, that the standard of Ægina was used at Corinth, and of course at Syracuse; and it appears from Aristotle, that the Sicilians had a talent or standard of their own. The Sicilian obolus or λιτρα contained also 12 ounces or *chalci*, so named at first because they weighed an ounce weight; but the ουγκιαι of Hiero weigh more than a troy ounce; and the brass coins of Agrigentum are marked with cyphers as far as six: the largest weighing only 186 grains, or about one-third of the primitive ounce. Our author denies that even the Roman denarius took its rise from the Sicilian δεκαλιτρον, as many authors assert. Were this the case, it would have weighed 180 grains; whereas the Roman denarii are not above the third part of the quantity.

46 Origin of the Sicilian coins.

From all these considerations, our author is of opinion that the Sicilians borrowed the division of their λιτρα from the Etruscans, or possibly from the Romans themselves; which our author thinks is more probable than that the Romans had it from Sicily. The strongest argument, however, against the Roman coinage being borrowed from the Sicilian is, that though great numbers of Sicilian coins are to be found in the cabinets of medalists, yet none of them resemble the *as libralis* of the Romans in any degree. In most cabinets also there are Etruscan coins upon the exact scale of the *as libralis*, and several of its divisions; from whence Mr Pinkerton concludes, that "these, and these alone, must have afforded a pattern to the primitive Roman coinage." The Etruscans were a colony from Lydia, to which country Herodotus ascribes the first invention of coinage. "Those colonists (says Mr Pinkerton), upon looking round their settlements, and finding that *no* silver was to be had, and *much less* gold," supplied the mercantile medium with copper; to which the case of Sweden is very similar, which, as late as the last century, had copper coins of such magnitude, that wheelbarrows were used to carry off a sum not very considerable.

47 Of the most ancient Roman coins.

Some coins are found which exceed the *as libralis* in weight; and these are supposed to be prior to the time of Servius Tullius. Some of them are met with of 34 and of 53 Roman ounces; having upon one side the figure of a bull rudely impressed, and upon the other the bones of a fish. They are most commonly found at Tudder, or Tudertum, in Umbria; but they appear always broken at one end: so that Mr Pinkerton is of opinion, that perhaps some might be struck of the decussis form, or weighing ten pounds. These pieces, in our author's opinion, make it evident, that the Romans derived their large brass coins from the Etruscans and the neighbouring states: they are all cast in moulds; and the greater part of them appear much more ancient than the Roman ases, even such as are of the greatest antiquity.

Mr Pinkerton agrees with Sir Isaac Newton as to the time that Servius Tullius reigned in Rome, which he supposes to be about 460 B. C. His coinage seems to have been confined to the as, or piece of brass having the impression of Janus on the one side, and the prow of a ship on the other; because Janus arrived in Italy by sea. Varro, however, informs us, that the very first coins of Tullius had the figure of a bull or other cattle upon them, like the Etruscan coins, of which they were imitations. Those with the figure of Janus and the prow of a ship upon them may be supposed first to have appeared about 400 B. C. but in a short time, various subdivisions of the as were coined. The *semis*, or half, is commonly stamped with the head of

48 Subdivisions of the as.

Jupiter

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Jupiter laureated; the *triens* or third, having four cyphers, as being originally of four ounces weight, has the head of Minerva; the *quadrans* or quarter, marked with three cyphers, has the head of Hercules wrapt in the lion's skin; the *sextans* or sixth, having only two cyphers, is marked with the head of Mercury with a cap and wings; while the *uncia* having only one cypher, is marked with the head of Rome. All these coins appear to have been cast in moulds, by a considerable number at a time; and in the British museum there are four of them all united together as taken out of the mould in which perhaps dozens were cast together. In process of time, however, the smaller divisions were struck instead of being cast; but the larger still continued to be cast until the as fell to two ounces. Even after this time it was still called *libra*, and accounted a pound of copper; though there

49 Larger denominations of it struck.

were now larger denominations of it coined, such as the *bissas* or double as; *tressis* and *quadrussis* of three and four ases; nay, as far as *decussis* or ten ases, marked X. Olivieri mentions one in his own cabinet weighing upwards of 25 ounces, and cast when the as was about three ounces weight. There is likewise in the Musæum Etruscum a decussis of 40 Roman ounces, cast when the as was at four ounces. There was likewise a curious decussis in the Jesuits library at Rome, for which an English medallist offered 20l.; but it was seized by the pope along with every other thing belonging to the society.

50 Decrease of the as in weight.

Mr Pinkerton contests the opinion of Pliny that the as continued of a pound weight till the end of the first Punic war. His opinion (he says), is confuted by the coins which still remain; and it appears probable to him that the as decreased gradually in weight; and from one or two of the pieces which still exist, he seems to think that the decrease was slow, as from a pound to eleven ounces, then to ten, nine, &c.; but neither the as nor its parts were ever correctly sized. During the time of the second Punic war, when the Romans were sore pressed by Hannibal, the as was reduced to a single ounce. It is said to have taken place in the 215th year before our era, being about 36 years after the former change. This as libralis, with the faces of Janus upon it, is the form most commonly met with previous to its being reduced to two ounces. Our author supposes that the as libralis continued for at least a century and a half after this coinage of Tullius down to 300 B.C. about the year of Rome 452, between which and the 502d year of Rome a gradual diminution of the as to two ounces must have taken place. The following table of the dates of the Roman coinage is given by Mr Pinkerton.

The libralis, coined by Tullius with the figures of oxen, &c. about 167 years after the building of Rome, according to Sir Isaac Newton, or about the year before Christ	460
As liberalis with Janus and the prow of a ship	400
As of ten ounces - - -	300
Eight - - - -	290
Six - - - - -	280
Four - - - - -	270
Three - - - - -	260
Two, according to Pliny - -	250
One, according to the same author -	214

About 175 B.C. also, we are informed by Pliny that the as was reduced to half an ounce by the Papyrian law, at which it continued till the time of Pliny himself, and long after.

After the Romans began to have an intercourse with Greece, a variety of elegant figures appear upon the parts of the as, though not on the as itself till after the time of Sylla. Towards the latter end of the republic also, *dupondii*, or double ases, were coined, together with the sestertii ærei, which came in place of the *quadrusses*, when the denarius began to be reckoned at 16 ases; probably at the time the latter was reduced to half an ounce. In some instances it is to be observed, that the Romans accommodated their coins to the country where their army was stationed; whence we have many coins marked as Roman, which have been coined in Magna Græcia and Sicily, and are evidently upon the Greek and not the Roman scale. In the latter part of the republican times, also, the types begin to vary; so that we have a brass coin supposed to be struck by Sextus Pompeius in Sicily, having upon it a double head of that warrior, representing a Janus. Mr Pinkerton supposes it to have been a dupondius; which indeed appears to be the case from the double head. This coin is of copper, and still weighs an ounce, notwithstanding its antiquity.

51 Coins on the Greek scale marked as Roman.

52 Of the sestertius.

The largest imperial copper coin was the sestertius, a piece worth about twopence of our money. Mr Pinkerton censures severely the opinion of other medallists, all of whom say that the sestertius was of silver. "In fact (says he), it would be as rational in any antiquary, a thousand years hence, to contend that the halfpenny and farthing are of silver, because they were so in the reign of Henry VIII." In confirmation of his own opinion, he quotes the following passage from Pliny: "The greatest glory of brass is now due to the Marian, called also that of Cordova. This, after the Livian, most absorbs the lapis calaminaris, and imitates the goodness of native orichalcum in our sestertii and dupondiarii, the ases being contented with their own copper." Gronovius confesses that he does not know what to make of this passage, and that it causes him hesitate in his opinion. The *Livian* mine mentioned here by Pliny, is supposed to have got its name from *Livia* the wife of Augustus; and it is probable that the pieces marked with her portraits, entitled Justitia, Salus, Virtus, &c. were dupondii from this very mine, the metal being exceedingly fine, and of the kind named *Corinthian brass* by the ancient medallists. "Perhaps (says Mr Pinkerton), the mine received its name from this very circumstance of her coins being struck in the metal taken from it."

53 Coinage of yellow brass.

No change took place in the Roman coinage from the time that the as fell to half an ounce to the days of Pliny: but Mr Pinkerton observes, that before the time of Julius Cæsar yellow brass began to be used, and was always looked upon to be double the value of Cyprian or red copper. There are but few coins in large brass immediately before Julius Cæsar, or even belonging to that emperor; but from the time of Augustus downward, the large coins are all found of brass, and not one of them copper. The largest of what are called the middle size are all of yellow brass; and the next size, which is the as, and weighs half an ounce, is universally copper. What the ancients named

med *orichalcum*, or what we call *brass*, was always looked upon to be greatly superior in value to the æs Cyprium. Procopius, speaking of a statue of Justinian, tells us, that brass inferior in colour to gold is almost equal in value to silver. The mines of native brass were very few in number, and were owing entirely to the singular combination of copper and lapis calaminaris in the bowels of the earth, which very seldom occurs; and the ancients were very far from being well acquainted with the method of combining these two bodies artificially; so that yellow brass was always esteemed at double the value of copper; and hence, in the ancient coinages, the brass and copper pieces were kept as distinct as those of gold and silver.

Mr Pinkerton challenges to himself the discovery that the imperial sestertius was of brass; and is at considerable pains to bring proofs of it. Besides the testimony of Pliny, which of itself would be decisive, this is supported by the strongest collateral evidence of other authors. From a passage in Julius Africanus, who wrote the Ιατρικα, or *Treatise on Medicine*, it appears that the nummus, or sestertius, weighed an ounce, and of consequence that it could not be silver but brass; and all the large imperial Roman coins weigh an ounce. We know not the age in which Julius Africanus lived; and as he makes the denarius to contain 16 ases, he must have been before the age of Gallienus, when it had 60. Gronovius supposes him to have been the same mentioned by Eusebius. This author speaks of a Julius Africanus who lived in the time of Heliogabalus, and whom Mr Pinkerton supposes to have been the same with him above mentioned.

54 Diminution of the sestertius.

The sestertius underwent no change till the time of Alexander Severus, when it was diminished by one-third of its weight. Trajanus Decius was the first who coined double sestertii, or quinarii, of brass; but from the time of Trebonianus Gallus to that of Gallienus, when the first brass ceases, the sestertius does not weigh above the third part of an ounce; the larger coins are accounted double sestertii; and after the time of Gallienus it totally vanishes. In the times of Valerian and Gallienus we find a new kind of coinage, mentioned by the name of *denarii æris*, or *Philippi ærei*. Two sizes of denarii began to be used in the time of Caracalla; the larger of six sestertii, or 24 assaria; the smaller of four sestertii, or 16 assaria as usual. In the time of Pupienus, the latter was reduced to such a small size as not to weigh more than 36 grains; though in Caracalla's time it weighed 56. After the time of Gordian III. the smaller coin fell into disuse, as breeding confusion. The larger denarius of six sestertii, though diminished at last to the size of the early denarius, still retained its value of six sestertii, or 24 assaria. The *Philippus æreus* came at length in place of the sestertius. It was also called *denarius;* from which we may learn not only their size, but that they were in value ten assaria as the first denarius. In the reign of Dioclesian, the place of the sestertius was supplied by the *follis*, that emperor having restored the silver coin to its purity, and likewise given this form to the copper; but it would seem that this restoration of the coinage only took place towards the end of his reign; whence we have but few of his silver coins, and still fewer of the *follis*, though the *denarii æerei* continue quite common down to the time of Constantine. The follis of Dioclesian seems to have weighed above half an ounce; and Mr Pinkerton is of opinion, that Dioclesian designed this coin to supply the place of the denarius æreus; which of course was worth ten assariæ, and six of them went to the silver denarius. From this time the assarium diminishes to the size of 30 grains; and soon after the follis appeared, the denarius æreus was entirely dropped, the former having gradually supplied its place. Some mints appear to have retained the use of the denarius longer than others; and in some the change was preceded, and gradually brought in, by washing the follis with silver or tin, as the denarius had formerly been. Pieces of this kind occur in the times of Dioclesian, Maximian I. and II. and Constantius I.; that is, for about ten years after the follis made its appearance. Some countries, however, retained the denarius æreus; others the follis; and some had a medium betwixt the two, or the follis washed in imitation of the denarius.

55 New coinage introduced by Constantine I.

Towards the end of the reign of Constantine I. a new coinage was introduced throughout the whole empire. The follis coined by this prince was of half an ounce weight; 24 of them going to the milliarensis, or larger silver coin. The word *follis* signifies also a purse, in which sense we sometimes find it mentioned in the Byzantine history. The common follis of silver, when it occurs by itself, means a purse of 250 milliarenses, as the sestertium was 250 denarii; and by a law of Constantine I. every man paid to the state a follis or purse according to his income. The method of counting by purses continues in Turkey to this day.

56 Of the dupondius.

The *dupondius* was only half the value of the sestertius, or about one penny sterling; and before the yellow brass appeared it seems to have been struck upon copper, and double the size of the as. There are some of this coin, struck in the time of Julius Cæsar, in yellow brass, weighing half an ounce, with a head of Venus Victrix upon one side; on the reverse, a female figure, with serpents at her feet: while others have a Victory on the reverse, with Q. Oppius Pr. After the time of Augustus, the dupondius was struck in yellow brass; which Pliny tells us was also the case in his time. The word dupondiarius seems to have been used by Pliny, and adopted, not to express that the coin was *dupondius*, but that it was of dupondiary value. Neither was the former word confined to signify double weight, but was used also for double length or measure, as in the instance of *dupondius pes*, or two feet, &c. In the imperial times, therefore, *dupondius* was used, not to signify a coin of double the weight of the as, but of double the value. It was one of the most common of the Roman coins; and seems to have been very common even in Constantinople. In the time of Justinian, it seems there was a custom of nicknaming young students of the law *dupondii*, against which the emperor made a law; but it is not known what gave rise to the name. The dupondius, though of the same size with the as, is commonly of finer workmanship, the metal being greatly superior in value. It continues to be of yellow brass, as well as the sestertius to the time of Gallienus; but the as is always in copper.

57 Of the assarium.

The imperial as, or *assarium*, was worth only a halfpenny.

halfpenny. At first it weighed half an ounce, and was always of copper till the time of Gallienus, when it was made of brass, and weighed only the eighth part of an ounce. From the time of Gallienus to that of Dioclesian, it continued to diminish still more, the size being then twenty to an ounce. This was the same with the lepta, or smallest coins but the νουμια, which weighed only ten grains.

58 Parts of the as.

The parts of the as occur but seldom: which may, indeed, be well expected, considering the low value of it; though there still occur some of those called semis, triens, quadrans, sextans, and uncia, coined in the times of Nero and Domitian. There is no small brass from the time of Pertinax to that of Gallienus, excepting that of Trajanus Decius; but in the time of Gallienus it becomes extremely common; and the coins of small brass, as well as the larger, are always marked S. C. such as want it being universally accounted forgeries; and were plated with silver, though the plating be now worn off. The small pieces struck for slaves during the time of the saturnalia, must also be distinguished from the parts of the as. The S. C. upon these most probably signifies *Saturni Consulto*, and were struck in ridicule of the true coins, as the slaves on that occasion had every privilege of irony.

59 Of the smallest Roman coins.

The sestertius diminishes from Pertinax to Gallienus so fast, that no parts of the as are struck, itself being so small. Trajanus Decius, indeed, coined some small pieces, which went for the semis of the time. The small brass coins under Gallienus were called assaria, sixty of which went to the silver denarius. They are about the size of the denarius, and some of them occur of the coinage of Gallus and his family, of half that size, which appear to have been struck during the latter part of his reign, when the assarium was diminished to a still smaller size. It is probable, however, that some of these very small coins had been struck in all ages of the empire, in order to scatter among the people on solemn occasions. Mr Pinkerton is of opinion that they are the *missilia*, though most other medallists think that they are medallions. "But if so (says our author), they were certainly called *missilia à non mittendo*; for it would be odd if fine medallions were scattered among the mob. It is a common custom just now to strike counters to scatter among the populace on such occasions, while medals are given to peers of the kingdom; and we may very justly reason from analogy on this occasion."

60 Of the missilia.

The *assarion* or *lepton* of the Constantinopolitan empire was, as we have already observed, one of the smallest coins known in antiquity, weighing no more than 20 grains; and the *noumia* were the very smallest which have reached our times, being only one half of the former. By reason of their extreme smallness, they are very scarce; but Mr Pinkerton informs us, that he has in his possesion a fine one of Theodosius II. which has on it the emperor's head in profile. Theodosius P. F. AV.; on the reverse a wreath, having in the centre VOT. XX.: MULT. XXX.

61 Coins of the lower empire.

The principal coin of the lower empire was the follis, which was divided into an half and quarter, named ἡμισοφολεος and τεταρτον; that latter of which is shown by Du Cange to have been a small brass coin, as the other is supposed to have been by Mr Pinkerton.—Besides these, the follis was divided into eight oboli, 16 assaria or lepta, and 32 noumia, though in common computation it contained 40 of these last. This coin, notwithstanding so many divisions, was of no more value than a halfpenny.

Mr Pinkerton controverts an opinion, common among medallists, that the largest brass coin or follis of the lower empire had 40 small coins, expressed by the letter M upon it; the next had 30, expressed by the letter Λ; the half by the letter K; and the quarter marked I, which contained only 10. Mr Pinkerton informs us, that he has three coins of Anastasius, all marked M in large; one of them weighs more than half an ounce; the second 40 grains less; and the third of 160 grains, or one-third of an ounce; but the size is so very unequal, that the last, which is very thick, does not appear above half the size of the first. There are pieces of Justinian which weigh a whole ounce; but the size of copper was increased as the silver became scarcer; and the value of the coinage cannot be deduced from the weight of the coins, as it is plain that our own coinage is not of half the value with regard to the metal. A great number of medallions were struck by Constantius II. but there is no other copper larger than the half ounce, excepting that of Anastasius, when the follis began to be struck larger. All medallists allow the others to be medallions.

The metal employed in these very small coins, though at first of brass, was always a base and refuse kind; but copper is generally made use of in the parts of the as from the earliest times to the latest; and if brass be sometimes employed, it is never such as appears in the sestertii and dupondiarii, which is very fine and beautiful, but only the refuse. "Yellow brass of the right sort (says Mr Pinkerton), seems totally to have ceased in the Roman coinage with the sestertius, under Gallienus, though a few small coins of very bad metal appear under that hue as late as Julian II."

Silver was coined in Rome only as late as the 485th year of the city, or 266 B. C. Varro indeed speaks of silver having been coined by Servius Tullius, and the libella having been once in silver; but Pliny's authority must be accounted of more weight than that of this author, as he mistakes the λιτρα of Sicily for Roman coins, having been current at Rome during the time of the first Punic war. Even Pliny, according to our author, very frequently mistakes with regard to matters much antecedent to his own time; and among the moderns he criticises severely Erasmus and Hume. "Erasmus (says he), who had been in England for some time, talks of leaden money being used here." Not even a leaden token was struck in the reign of Henry VIII.; yet his authority has been followed with due deference to so great a name; for how could Erasmus, who must have seen the matter with his own eyes, assert a direct falsehood? To give a later instance in a writer of reputation, Mr Hume, in Vol. VI. of his history, has these words, in treating of the reign of James I. "It appears that copper halfpence and farthings began to be coined in this reign. Tradesmen had commonly carried on their retail business by leaden tokens. The small siver penny was soon lost; and at this time was nowhere to be found." Copper halfpence and farthings were not struck till Charles II. 1672: there were small tokens for

62 Roman silver.

An...nt Mo...y.

for farthings struck in copper by James I. but not one for the halfpenny. The silver farthings had ceased with Edward VI. but the silver halfpence continued the sole coins till Edward II. It was by copper tokens that small business was carried on. The silver penny was much used till the end of the reign of George I.; and so far from being nowhere to be found, is superabundant of every reign since that period, not excepting even the present reign of George III. From these instances the reader may judge how strangely writers of all ages blunder, when treating of a subject of which they are entirely ignorant."

Dena... when ...st coine...

The first silver denarii coined at Rome, are supposed by our author to have been those which are impressed with the ROMA; and he inclines to account those the most ancient that have a double female head on the one side, and on the reverse Jupiter in a car, with Victory holding the reins, and the word ROMA indented in a rude and singular manner. The double female head seems to denote Rome, in imitation of the Janus then upon the as. There are 15 of these in the cabinet of Dr Hunter; one of the largest weighs 98¼ grains: and the rest, which seem to be of the greatest antiquity, are of various weights betwixt that and 84; the smaller and more modern weigh 58 or 59 grains; but Mr Pinkerton is of opinion, that the large ones are of the very first Roman coinage, and struck during that interval of time betwixt the coinage of the first silver denarius and the as of two ounces. He takes the indentation of the word ROMA to be a mark of great antiquity; such a mode being scarcely known any where else, except in Caulonia, Crotona, and other towns of Italy; all of them allowed to be struck at least 400 B. C. As these coins are not double denarii, they must have been struck prior to the small ones; and Nenmann has given an account of one of them recoined by Trajan, in which the indentation of ROMA is carefully preserved. The first denarius was in value 10 ases, when the as weighed three ounces; and allowing 90 grains at a medium for one of these large denarii, the proportion of copper to silver must have been as 1 to 160: but when the as fell to one ounce, the proportion was as 1 to 80; when it fell to half an ounce, so that 16 ases went to the denarius, the proportion was as 1 to 64, at which it remained. Copper with us, in coinage, is to silver as one to 40; but in actual value as 1 to 72.

Valu... of the d...rius a... its parts.

At Rome the denarius was worth 8d.; the quinarius 4d.; and the sestertius, whether silver or brass, 2d. The denarius is the coin from which our penny is derived, and was the chief silver coin in Rome for 600 years. According to Celsus, seven denarii went to the Roman ounce, which in metals did not exceed 430 grains; but as all the denarii hitherto met with weigh at a medium only 60 grains, this would seem to make the Roman ounce only 420 grains; though perhaps this deficiency may be accounted for from the unavoidable waste of metal even in the best preserved of these coins. According to this proportion the Roman pound contained 84 denarii; but in tale there was a very considerable excess; for no fewer than 100 denarii went to the Roman pound. The Greek ounce appears to have been considerably larger than that of Rome, containing about 528 grains; yet notwithstanding this apparently great odds, the difference in the coins was so small, that the Greek money went current in Rome, and the Roman in Greece. The denarius at first went for 10 ases, and was marked X: it was afterwards raised to 16; which Mr Pinkerton supposes to have been about 175 B. C. Some are met with bearing the number XVI. nay, with every number up to CCCCLXXVI. These large numbers are supposed to have been mint-marks of some kind or other. After being raised to 16 ases, it continued at the same value till the time of Gallienus; so that till that time we are to look upon its constituent parts to be 16 ases or assaria, eight dupondii, four brass sestertii, and two silver quinarii. Under the emperor Severus, however, or his successor Caracalla, denarii were struck of two sizes, one of them a third heavier than the common; which we must of consequence suppose to have borne a third more value. This large piece obtained the name of *argentus*, and *argenteus Philippus*, or the "silver Philip;" the name of Philip having become common to almost every coin. The common denarii now began to be termed *minuti* and *argenti Philippi minutuli*, &c. to express their being smaller than the rest. Some have imagined that the large denarii were of the same value with the small, only of worse metal; but Mr Pinkerton observes, that among the few which have any difference of metal, the smallest are always the worst. The first mention of the *minuti* is in the time of Alexander Severus, who reduced the price of pork from eight minuti at Rome to two and to one. The *minutus argenteus* of that age was about 40 grains; and from the badness of the metal was not worth above 4d. of our money. Thus the price of meat was by this prince reduced first to 8d. and then to 4d.

65 Restoration of the purity of the Roman coins.

According to Zozimus and other writers, the purity of the Roman coin was restored by Aurelian: but Mr Pinkerton controverts this opinion; thinking it more probable, that he only made the attempt without success; or that his reformation might be entirely confined to gold, on which there is an evident change after the time of this emperor. His successor Tacitus is said to have allowed no brass to be mixed with silver upon any account; yet the few coins of this emperor are very much alloyed. We are certain, however, that the emperor Dioclesian restored the silver to its ancient purity; the denarii struck in his reign being very small indeed, but of as fine silver as the most ancient coins of the empire. After Gordian III. the small denarius entirely vanished, while the large one was so much diminished, that it resembled the *minutus*, or small one of Caracalla, in size. Gallienus introduced the *denarii ærei* instead of the *sestertii*. The *argenteus*, though reduced more than one-third in size, contained six denarii ærei, the old standard of sestertii. According to the writers of this period, and some time afterwards, the denarius or argenteus contained 60 assaria; whence it follows, that each denarius æreus had 10; and from this it probably had its name. The assaria are of the size of the argentei already mentioned; and show the copper to have retained nearly its old proportion of value to the silver, viz. 1 to 60.

66 Reformation of the silver coin by Constantine.

A larger silver coin was introduced by Constantine I. who accommodated the new money to the pound of gold in such a manner, that 1000 of the former in tale were equal to the latter in value; so that this new piece from thence obtained the name of the *milliarensis*

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milliarensis or "thousander." Its weight at a medium is 70 grains, or 70 to the pound of silver: but Mr Pinkerton is of opinion, that it might have contained 72 grains, of which two have now perished by the softness of the silver; that the pound contained 72; or that two of the number might be allowed for coinage; while the alloy alone would pay for coining gold. The code says, that 60 went to the pound; but the numbers of this are quite corrupt. The *milliarensis* was worth about a shilling sterling. The argentei or denarii, however, were still the most common currency; and having been originally rated at 100 to the pound of silver in tale, they from thence began to be called *centenionales*, or "hundreders." Those of Constantine I. and II. Constans, and Constantius, weigh from 50 grains down to 40; those of Julian and Jovian, from 40 to 30; and of the succeeding emperors from that time to Justinian, from 30 to 20. Under Heraclius they ceased entirely; and from Justinian to their total abolition, had been brought down from 15 to 10 grains. A like decrease of weight took place in the milliarensis; those of Constantine and Constans being above 70 grains in weight; those of Arcadius not above 60; and the milliarensis of Justinian not more than 30 grains; but, from the weight of those in Dr Hunter's cabinet, Mr Pinkerton deduces the medium to have been exactly $70\frac{8}{11}$ grains. These coins were also called *majorinæ*.

67 Account of the small Roman coins.

The smaller silver coins of Rome were, 1. The *quinarius*, at first called *victoriatus*, from the image of Victory on its reverse; and which it continued to bear from first to last. Its original value was five ases, but it was afterwards raised to eight, when the value of the denarius increased to 16. According to Pliny, it was first coined in consequence of the *lex Clodia*, about the 525th year of Rome. Some are of opinion, that it was called κεϱατιον under the Constantinopolitan empire, because it was worth a κεϱατιον of gold, 144 of which went to the ounce: but this is denied by Mr Pinkerton, because, at the time that the word κεϱατιον first appears in history, the denarius did not weigh above 30 grains; and of consequence, as 25 must have gone to the gold solidus, of which there were six in the ounce, 130 denarii must have gone to the ounce of gold. He is therefore of opinion, that the word κεϱατιον, was only another name for the denarius when much reduced in size; probably owing to the great scarcity of silver in Constantinople, though in the same city there was plenty of gold; and of consequence, the gold solidus was never diminished. "For Montesquieu (says our author) has well observed, that gold must be common where silver is rare. Hence gold was the common regulation of accounts in the Eastern empire." The διxεϱατιον met with in ancient authors, according to Mr Pinkerton, was merely an improper name for the *milliarensis;* when, on account of the scarcity of silver, the denarius was reduced, and no milliarenses coined: so that the current milliarensis of former reigns happened to be double to the denarius or centenionalis. The quinarius diminishes in size along with the other coins; those of Augustus weighing 30 grains, of Severus 25, of Constantine I. 20, of Justinian 12, and of Heraclius only 5. A new silver coinage seems to have taken place after the days of this emperor; as the little we then meet with, which in the best cabinets scarce exceeds a dozen of coins, consists entirely of large unshapely pieces of coarse metal.

68 Division of the denarius.

2. The consular denarius had also four silver sestertii, till the as fell to half an ounce, when it was thought proper to coin the sestertius in brass, as it continued to be ever afterwards. "The very last silver sestertius (says Mr Pinkerton) which appears, is one with a head of Mercury, and H. S.; on the reverse a caduceus P. SEPVLLIVS; who appears to be the P. SEPVLLIVS MACER of the denarii of Julius Cæsar. If so, as is most probable, the sestertius was coined in silver down to Augustus; and it is of course not to be expected that any of brass can appear till Augustus, under whom they are actually quite common. I have indeed seen no coin which could be a consular brass sestertius; and though we have certainly brass dupondii of Cæsar, yet it is reasonable to infer, that the brass sestertius was first coined by Augustus. Not one silver sestertius appears during the whole imperial period, yet we know that the sestertius was the most common of all silver coins. The consular sestertii of silver, marked H. S. are not uncommon, nor the quinarii; but the latter are very scarce of all the emperors, if we except one instance, the ASIA RECEPTA of Augustus.

69 Roman gold.

"The Roman gold coinage was still later than that of silver. Pliny tells us, that "gold was coined 62 years after silver,; and the scruple went for 60 sesterces. It was afterwards thought proper to coin 40 pieces out of the pound of gold. And our princes have by degrees diminished their weight to 45 in the pound." This account is confirmed by the pieces which still remain; for we have that very coin weighing a scruple, which went for 20 sesterces. On one side is the head of Mars, and on the other an eagle; and it is marked XX. We have another coin of the same kind, but double, marked XXXX; and its triple, marked ↓X or 60; the ↓ being the old numeral character for 50. Mr Pinkerton, the discoverer of this, treats other medallists with great asperity. Savot and Hardouin are mentioned by name; the latter (he says) is "ignorant of common sense;" and neither he nor Savot could explain it but by reading backward; putting the ↓ for the Roman V, and thus making it XV. Other readings have been given by various medallists, but none have hit upon the true one excepting our author, though the coin itself led to it; being just three times the weight of that marked XX. We have likewise half the largest coin, which is marked XXX, and which weighs 26 grains; the smallest is only $17\frac{1}{2}$; the XXXX weighs 34; and the LX or drachma 53. There is also the didrachm of this coinage, of 106 grains.

70 Account of the aurei.

The *aurei*, or Roman gold coins, were at first 48 in the pound; but they were afterwards diminished in number to 40, owing to an augmentation in the weight of each coin. In the time of Sylla, the aureus weighed no less than from 164 to 168 grains, and there were only 30 in the pound; but such confusion in the coinage was introduced by that conqueror, that no person could know exactly what he was worth. Till this time the aureus seems to have continued of the value of 30 silver denarii, about one pound sterling; for about that time it was enlarged a whole third, that

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that it might still be equivalent to the full number of denarii. But after Sylla had taken Athens, and the arts and manners of Greece became objects of imitation to the Romans, the aureus fell to 40 in the pound, probably when Sylla had abdicated his dictatorship. Thus, being reduced near to the scale of the Greek χρυσος, it passed for 20 denarii, as the latter did for as many drachmas, being in currency 13s. 4d. sterling. "This (says Mr Pinkerton) is the more probable, because we know from Suetonius, that the great Cæsar brought from Gaul so much gold, that it sold for nine times its weight of silver: but the Gallic gold was of a very base sort."

In the time of Claudius, the aureus was valued at 100 sesterii, or 25 silver denarii, at which it continued till the time of Heliogabalus, when it fell to about 92 grains at a medium, or rose in number to 55 in the pound. In the reign of Philip, during which the city completed its thousandth year, the aureus was coined of two or three sizes. These are impressed with a head of Rome on one side, and various figures on the other; but the workmanship is so rude, that they are supposed to have been struck in some of the more uncivilized provinces of the empire. The practice of having different gold coins, however, continued under Valerian, Gallienus, and his successors. In the time of Gallienus, they were of 30, 65, and from 86 to 93 grains; the double aurei being from 172 to 183½ grains; but the aureus properly so called was from 86 to 93; those of 30 and 32 being the *trientes aurei* of the *Historiæ Augustæ Scriptores;* while the larger, from 62 to 65, are to be accounted double trientes, and were perhaps called *minuti aurei*. The value of these different sizes of aurei is not known.

Alteration in the gold coin by Aurelian.

That Aurelian made some alteration in the coin is certain; but Mr Pinkerton supposes it to have been only in the gold; because under him and his successor Probus, the common aureus was of 100 grains, a size confined to those emperors: there are likewise halves of about 50 grains; and double aurei, commonly of very fine workmanship, of upwards of 200 grains. In the time of Gallienus, the precious metal was so common, that this emperor vied in magnificence with Nero and Heliogabalus. Aurelian, who plundered the rich city of Palmyra, and thus became master of the treasures of the east, obtained such a profusion of gold, that he looked upon it to be produced by nature in greater plenty than silver. It is remarkable that during this emperor's reign there was a rebellion among the money coiners, which could not be quelled but by the destruction of several thousands; which Mr Pinkerton ascribes to his having ordered the gold to be restored to its former size, but to go for no more silver than it formerly did. "So very little silver (says he) occurs of this period, that it is plain no alteration in the silver produced the war with the moneyers; and in the brass he made no change; or if he had, it were strange that such commotions should arise about so trifling a metal. But if, as appears from the coins, he ordered the aureus, which had fallen to 80 grains, to be raised to about 100, it is no wonder that the contractors should be in an uproar; for a whole quarter of their coinage, amounting as would seem, to all their profits, was lost. Aurelian judged, that when he found gold so common in the east, it was equally so in the west; and that the moneyers must have made a most exorbitant profit; but his ideas on this subject were partial and unjust: and after his short reign, which did not exceed five months after the alteration, the gold returned to its former course; though a few pieces occur of Aurelian's standard, struck, as would seem, in the commencement of the reign of Probus his successor.

From this time to that of Constantine I. the aureus weighed between 70 and 80 grains; but in his reign it was changed for the solidus, of which six went to the ounce of gold, which went for 14 milliarenses, and 25 denarii as before; the value of silver being now to gold as 14 to 1. This new coin continued of the same value to the final downfall of the Constantinopolitan empire; gold being always very plentiful in that city, though silver became more and more scarce. The solidus was worth 12s. sterling. Here again our author most severely criticises Mr Clarke and Mr Raper: the former (he says) with respect to the value of gold in the time of Constantine I. "has left all his senses behind him. In page 267, he absurdly asserts, that 20 denarii went to the solidus in the time of Theodosius I. and proceeds with this deplorable error to the end of his work. He then tells us, that only 14 denarii went to the solidus under Constantine I.," &c. To Mr Raper, however, he is a little more merciful, as he owns, that "though he (Mr Raper) has strangely confounded the milliarensis with the denarius, he has yet kept common sense for his guide." Mr Pinkerton, indeed, argues with great probability, "that had any change in the coinage taken place between the time of Constantine and Theodosius I. that is, in less than 50 years, the laws of that period, which are all in the Theodosian code, must have noticed it." To this and other arguments upon the subject, Mr Pinkerton adds the following observation upon the value of gold and silver: "As a state advances to its height, gold increases in value; and as a state declines, it decreases, providing the metals are kept on a par as to purity. Hence we may argue, that gold decreased in its relation to silver perhaps four or five centuries, furnished most European kingdoms with gold in coin, which otherwise would, from their want of arts and of intercourse with the east, then the grand seminary of that metal, have almost been ignorant of what gold was. These gold coins were called *Bezants* in Europe, because sent from Byzantium or Constantinople; and were *solidi* of the old scale, six to the ounce. In Byzantine writers, the solidus is also called *nomisma*. or "the coin;" *crysinos*, because of gold; *hyperperos*, from its being refined with fire, or from its being of bright gold flaming like fire. The *solidi* also, as the *aurei* formerly, received names from the princes whose portraits they bore; as *Michelati*, *Manuelati*. *Solidus* is a term used also for the aureus by Apuleius, who lived in the time of Antoninus the Philosopher; nay, as early as the prætorian edicts of the time of Trajan. It was then a distinction from the semissis or half. In the time of Valerian, when aurei of different sizes had been introduced, it became necessary to distinguish the particular aurei meant. Hence in the Imperial Rescripts, published by the *Historiæ Augustæ Scriptores*, Valerian uses the term *Philippeos nostri vultus*, for the common aurei. Aurelian uses the same term *aurei*

U 2 *Philippei*,

Ancient Money.

Philippei, for the aurei which he had restored to their size in some degree. Gallienus uses *aurei Valeriani* for his father's coins. *Aurei Antoniniani* are likewise put by Valerian for coins of the early Antonini, of superior standard to any then used.

72
Division of the aureus.

In the first gold coinage at Rome the aureus was divided into four parts: the semissis of 60 sestertii; the tremissis or third, of 40; the fourth, the name of which is not mentioned, of 30; and the scrupulum of 20. But in a short time all of these fell into disuse, except the semissis or half, which is extremely scarce; so that it is probable that few have been struck. It is an erroneous opinion (according to Mr Pinkerton), that the semissis was called a *denarius aureus*. The aureus itself indeed had this name; but the name of *quinarius* is applied to the semissis with greater propriety than the former. Trientes, or tremisses of gold, are found of Valerian and his son Gallienus, and weigh about 30 grains. Those of Salonina the wife of Gallienus weigh 33 grains. Under the Constantinopolitan empire, tremisses again made their appearance; and from the time of Valentinian downwards, the thirds are the most common kinds of gold, being worth about 4s. sterling. The semissis is likewise mentioned, but none occur earlier than the time of Basiliscus. The gold tremissis was the pattern of the French and Spanish gold coins; as the silver denarius, in its diminished state, was of the Gothic and Saxon penny.

73
Account of the Roman method of coining.

We shall close this account of the Roman money with some remarks concerning the mint, and method of coinage. This at first seems to have been under the direction of the quæstor. About the time that silver was first coined in Rome, viz. about 266 B. C. the *triumviri monetales* were created. They were at first of senatorial rank, but were by Augustus chosen from among the equestrian; and the title of *triumviri* was continued till after the time of Caracalla; but under Aurelian there was probably but one master of the mint, called *rationalis;* and Mr Pinkerton is of opinion that the change took place under Gallienus. He seems also to have permitted the provincial cities to coin gold and silver, as well as to have altered the form of the mints in the capital, and to have ordered them all to strike money with Latin legends, and of the same forms; as in his time we first meet with coins with mint marks of cities and offices. The violent insurrection which took place in his reign has already been mentioned, as well as its probable cause; and Mr Gibbon has shown, that the concealed enemies of Aurelian took such advantage of this insurrection, that it cost 7000 of his best troops before it could be quelled. About this time the *procurator monetæ* seems to have succeeded the *rationalis* as director of the mint. In the colonies, the direction of the mint seems to have been given to the decemviri, whose names frequently occur in colonial coins; "which (says Mr Pinkerton), though generally of rude invention, and ruder execution, are yet often interesting and important."

The engraving of the ancient dies used in coinage was a work of much genius and labour; and at Rome Greek artists were generally employed in it; but it has been thought a matter of great surprise, that scarce any two ancient coins are to be found exactly the same. Hence some antiquaries have imagined that only a single coin was thrown off from each die. M. Beauvais informs us, that the only two Roman imperial coins of the first times which he had seen perfectly alike were those of the emperor Galba. It is, however, the opinion of the best judges, that a perfect similarity betwixt two medals is a very great reason for supposing one of them to be forged. "It must also be observed (says Mr Pinkerton), that the differences in coins, apparently from the same die, are often so minute as to escape an eye not used to microscopic observations of this sort. But it would be surprising if any two ancient coins were now found struck with the same die; for out of each million issued, not above one has reached us. Dies soon give way by the violence of the work, and the ancients had no puncheons nor matrices, but were forced to engrave many dies for the same coin. Even in our mint, upon sending for a shilling's worth of new halfpence, it will appear that three or four dies have been used. Sometimes the obverse of of the die gives way, sometimes the reverse; but among us it is renewed by puncheons, though with variations in the lettering or other minute strokes; while the ancients were forced to recur to another die differently engraven. The engravers of the die were called *cælatores;* other officers employed in the mint were the *spectatores*, *expectatores*, or *nummularii*. The melters were styled *fusarii*, *flatuarii*, and *flaturarii;* those who adjusted the weight were called *æquatores monetarum;* those who put the pieces into the die *suppositores*, and those who struck them *malleatores*. At the head of each office was an officer named *primicerius*, and the foreman was named *optio et exactor*."

In order to assist the high relief on the coins, the metal, after being melted and refined, was cast into bullets, as appears from the ancient coins not being cut or filed on the edges, but often cracked, and always rough and unequal. These bullets were then put into the die, and received the impression by repeated strokes of the hammer, though sometimes a machine appears to have been used for this purpose: for Boiterue informs us, that there was a picture of the Roman mintage in a grotto near Baiæ, where a machine was represented holding up a large stone as if to let it fall suddenly, and strike the coin at once. None of the ancient money was cast in moulds, excepting the most ancient and very large Roman brass, commonly called *weights*, and other Italian pieces of that sort; all the rest being mere forgeries of ancient and modern times. Some Roman moulds which have been found are a proof of this; and from these some medallists have erroneously imagined that the ancients first cast their money in moulds, and then stamped it, in order to make the impression more clear and sharp.

The ancients had some knowledge of the method of crenating the edges of their coins, which they did by cutting out regular notches upon them; and of this kind we find some of the Syrian and ancient consular coins, with a few others. The former were cast in this shape, and then struck; but the latter were crenated by incision, to prevent forgery, by showing the inside of the metal: however, the ancient forgers also found out a method of imitating this; for Mr Pinkerton informs us, that he had a Roman consular coin, of which the incisions, like the rest, were plated with silver over the copper.

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Sect. VI. *Of the Preservation of Medals.*

We now come to consider what it is that distinguishes one medal from another, and why some are so highly prized more than others. This, in general, besides its genuineness, consists in the high degree of preservation in which it is. This, by Mr Pinkerton, is called the *conservation* of medals, and is by him regarded as *good* and as *perfect*. In this, he says that a true judge is so nice, that he will reject even the rarest coins if in the least defaced either in the figures or legend. Some, however, are obliged to content themselves with those which are a little rubbed, while those of superior taste and abilities have in their cabinets only such as are in the very state in which they came from the mint; and such, he says, are the cabinets of Sir Robert Austin, and Mr Walpole, of Roman silver, at Strawberryhill. It is absolutely necessary, however, that a coin be in what is called *good* preservation; which in the Greek or Roman emperors, and the colonial coins, is supposed to be when the legends can be read with some difficulty; but when the conservation is perfect, and the coin just as it came from the mint, even the most common coins are valuable.

4 Br and cop best pre ved by rust the overs the

The fine rust, like varnish, which covers the surface of brass and copper coins, is found to be the best preserver of them; and is brought on by lying in a certain kind of soil. Gold cannot be contaminated but by iron mold, which happens when the coin lies in a soil impregnated with iron; but silver is susceptible of various kinds of rust, principally green and red; both of which yield to vinegar. In gold and silver coins the rust must be removed, as being prejudicial; but in brass and copper it is preservative and ornamental; a circumstance taken notice of by the ancients. "This fine rust (says Mr Pinkerton), which is indeed a natural varnish not imitable by the art of man, is sometimes a delicate blue, like that of a turquoise; sometimes of a bronze brown, equal to that observable in ancient statues of bronze, and so highly prized; and sometimes of an exquisite green, a little on the azure hue, which last is the most beautiful of all. It is also found of a fine purple, of olive, and of a cream colour or pale yellow: which last is exquisite, and shows the impression to as much advantage as paper of cream colour, used in all great foreign presses, does copperplates and printing. The Neapolitan patina (the rust in question) is of a light green; and when free from excrescence or blemish is very beautiful. Sometimes the purple patina gleams through an upper coat of another colour, with as fine effect as a variegated silk or gem. In a few instances a rust of a deeper green is found; and it is sometimes spotted with the red or bronze shade, which gives it quite the appearance of the East Indian stone called the *blood-stone*. These rusts are all, when the real product of time, as hard as the metal itself, and preserve it much better than any artificial varnish could have done; concealing at the same time not the most minute particle of the impression of the coin."

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5 M ls ho limi- nis l in val

The value of medals is lowered when any of the letters of the legend are misplaced; as a suspicion of forgery is thus induced. Such is the case with many of those of Claudius Gothicus. The same, or even greater, diminution in value takes place in such coins as have not been well fixed in the die, which has occasioned their slipping under the strokes of the hammer, and thus made a double or triple image. Many coins of this kind are found in which the one side is perfectly well formed, but the other blundered in the manner just mentioned. Another blemish, but of smaller moment, and which to some may be rather a recommendation, is when the workmen through inattention have put another coin into the die without taking out the former. Thus the coin is convex on one side, and concave on the other, having the same figure upon both its sides.

Preservation.

The medals said by the judges in this science to be *countermarked* are very rare, and highly valued. They have a small stamp impressed upon them, in some a head, in others a few letters, such as AUG: N. PROBUS, &c. which marks are supposed to imply an alteration in the value of the coin; as was the case with the countermarked coins of Henry VIII. and Queen Mary of Scotland. Some have a small hole through them; sometimes with a little ring fastened in it, having been used as ornaments; but this makes no alteration in their value. Neither is it any diminution in the value of a coin that it is split at the edges; for coins of undoubted antiquity have often been found in this state, the cause of which has been already explained. On the contrary, this cracking is generally considered as a great merit; but Mr Pinkerton suspects that one of these cracked coins has given rise to an error with respect to the wife of Carausius who reigned for some time in Britain. The inscription is read ORIUNA AUG: and there is a crack in the medal just before the O of oriuna. Without this crack Mr Pinkerton supposes that it would have been read FORTUNA AUG. 77 Countermarked medals.

Some particular soils have the property of giving silver a yellow colour as if it had been gilt. It naturally acquires a black colour through time, which any sulphureous vapour will bring on in a few minutes. From its being so susceptible of injuries, it was always mixed by the ancients with much alloy, in order to harden it. Hence the impressions of the ancient silver coins remain perfect to this day, while those of modern coins are obliterated in a few years. On this account Mr Pinkerton expresses a wish that modern states would allow a much greater proportion of alloy in their silver coin than they usually do. As gold admits of no rust except that from iron above-mentioned, the coins of this metal are generally in perfect conservation, and fresh as from the mint. 78 Silver and gold how tarnished.

To cleanse gold coins from this rust, it is best to steep them in aquafortis, which, though a very powerful solvent of other metals, has no effect upon gold. Silver may be cleansed by steeping for a day or two in vinegar, but more effectually by boiling in water with three parts of tartar and one of sea salt; on both these metals, however, the rust is always in spots, and never forms an entire incrustation as on brass or copper. The coins of these two metals must never be cleansed, as they would thus be rendered full of small holes eaten by the rust. Sometimes, however, they are found so totally obscured with rust, that nothing can be discovered upon them; in which case it is best to clear them with a graver; but it may also be done by boiling them for 24 hours in water with three 79 How to cleanse them.

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three parts of tartar and one of alum; not sea salt as in silver coins.

The high state of preservation in which ancient coins are usually found, is thus accounted for by Mr Hancarville. He observes, that the chief reason is

80 When ancient coins are in such a high state of preservation.

the custom of the ancient always to bury one or more coins with their dead, in order to pay for their passage over the river Styx. "From Phidon of Argos (says he) to Constantine I. are 36 generations: and from Magna Græcia to the Euphrates, from Cyrene to the Euxine sea, Grecian arts prevailed, and the inhabitants amounted to above 30,000,000. There died, therefore, in that time and region, not less than ten thousand millions of people, all of whom had coins of one sort or other buried with them. The tombs were sacred and untouched; and afterwards neglected, till modern curiosity or chance began to disclose them. The urn of Flavia Valentina, in Mr Towley's capital collection, contained seven brass coins of Antoninus Pius and Heliogabalus. Such are generally black, from being burnt with the dead. The best and freshest coins were used on these occasions from respect to the dead; and hence their fine conservation. At Syracuse a skeleton was found in a tomb, with a beautiful gold coin in its mouth; and innumerable other instances might be given, for hardly is a funeral urn found without coins. Other incidents also conspire to furnish us with numbers of ancient coins, though the above-recited circumstance be the chief cause of perfect conservation. In Sicily, the silver coins with the head of Proserpine were found in such numbers as to weigh 600 French livres or pounds. In the 16th century, 60,000 Roman coins were found at Modena, thought to be a military chest hid after the battle of Bedriacum, when Otho was defeated by Vitellius. Near Brest, in the year 1760, between 20 and 30,000 Roman coins were found. A treasure of gold coins of Lysimachus was found at Deva on the Marus; and Strabo, lib. vii. and Pausan. in *Attic.* tell that he was defeated by the Getæ; at which time this treasure seems to have fallen into their hands."

81 Number of ancient coins.

Thus Mr Pinkerton, from the authority of Mr Hancarville and others: but considering these vast numbers of coins found in various places, it seems surprising how so few should now remain in the cabinets of the curious, as the same author informs us that the whole of the different ancient coins known to us amount only to about 80,000, though he owns that the calculation cannot be esteemed accurate.

Sect. VII. *How to distinguish true Medals from counterfeits.*

The most difficult and the most important thing in the whole science of medals is the method of distinguishing the true from the counterfeit. The value put upon ancient coins made the forgery of them almost coeval with the science itself; and as no laws inflict a punishment upon such forgers, men of great genius and abilities have undertaken the trade: but whether to the real detriment of the science or not, is a matter of some doubt; for if only exact copies of genuine medals are sold for the originals, the imposition may be deemed trifling: but the case must be accounted very different, if people take it upon them to forge medals which never existed. At first the forgeries were extremely gross; and medals were forged of Priam, of Aristotle, Artemisia, Hannibal, and most of the other illustrious personages of antiquity. Most of these were done in such a manner, that the fraud could easily be discovered; but others have imposed even upon very learned men. Mr Pinkerton mentions a remarkable medal of the emperor Heraclius, representing him in a chariot on the reverse, with Greek and Latin inscriptions, which Joseph Scaliger and Lipsius imagined to have been struck in his own time, but which was certainly issued in Italy in the 15th century. "Other learned men (says our author) have been strangely misled, when speaking of coins; for to be learned in one subject excludes not gross ignorance in others. Budæus, de Asse, quotes a denarius of Cicero, M. TULL. Erasmus, in one of his Epistles, tells us with great gravity, that the gold coin of Brutus struck in Thrace, ΚΟΣΩΝ, bears the patriarch Noah coming out of the ark with his two sons, and takes the Roman eagle for the dove with the olive branch. Winkelman, in his letters informs us, that the small brass piece with Virgil's head, reverse EPO, is undoubtedly ancient Roman; and adds, that no knowledge of coins can be had out of Rome: but Winkelman, so conversant in statues, knew nothing of coins. It is from other artists and other productions that any danger of deceit arises. And there is no wonder that even the skilful are misled by such

82 Coins forged by excellent artists.

artists as have used this trade; for among them appear the names of Victor Gambello, Giovani del Cavino, called the PADUAN, and his son Alessandro Bassiano, likewise of Padua, Benvenuto Cellini, Alessandro Greco, Leo Aretino, Jacobo da Frezzo, Federigo Bonzagna, and Giovani Jacopo, his brother; Sebastiano Plumbo, Valerio de Vizenza, Gorlæus, a German, Carteron of Holland, and others, all or most of them of the 16th century; and Cavino the Paduan, who is the most famous, lived in the middle of that century. The forgeries of Cavino are held in no little esteem, being of wonderful execution. His and those of Carteron are the most numerous, many of the other artists here mentioned not having forged above two or three coins. Later forgers were Dervieu of Florence who confined himself to medallions, and Cogornier who gave coins of the 30 tyrants in small brass. The chief part of the forgeries of Greek medals which have come to my knowledge are of the first mentioned, and a very gross kind, representing persons who could never appear upon coin, such as Priam, Æneas, Plato, Alcibiades, Artemisia, and others. The real Greek coins were very little known or valued till the works of Goltzius appeared, which were happily posterior to the æra of the grand forgers. Why later forgers have seldom thought of counterfeiting them cannot be easily accounted for, if it is not owing to the masterly workmanship of the originals, which set all imitation at defiance. Forgeries, however, of most ancient coins may be met with, and of the Greek among the rest.

83 Roman forgeries more conspicuous than Greek

"The forgeries are more conspicuous among the Roman medals than any other kind of coins; but we are not to look upon all these as the work of modern artists. On the contrary, we are assured that many of them were fabricated in the times of the Romans themselves, some of them being even held in more estimation than the genuine coins themselves, on account of

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of their being plated, and otherwise executed in a manner to which modern forgers could never attain. Even the ancients held some of these counterfeits in such estimation, that Pliny informs us there were frequently many true denarii given for one false one."—Caracalla is said to have coined money of copper and lead plated with silver; and plated coins, the work of ancient forgers, occur of many Greek cities and princes; nay, there are even forgeries of barbaric coins. "Some Roman coins (says Mr Pinkerton), are found of iron or lead plated with brass, perhaps trials of the skill of the forger. Iron is the most common; but one decursio of Nero is known of lead plated with copper. Neumann justly observes, that no historic faith can be put in plated coins, and that most faulty reverses, &c. arise from plated coins not being noticed as such. Even of the Roman consular coins not very many have ever been forged. The celebrated silver denarius of Brutus, with the cap of liberty and two daggers, is the chief instance of a consular coin of which a counterfeit is known. But it is easily rejected by this mark: in the true coin the cap of liberty is below the guard or hilt of the daggers; in the false, the top of it rises above that hilt."

84 Denarius of Brutus.

85 Imperial medals.

The imperial series of medals is the grand object of modern medallic forgeries; and the deception was at first extended to the most eminent writers upon the subject. The counterfeits are by Mr Pinkerton divided into six classes.

I. Such as are known to be imitations, but valued on account of the artists by whom they are executed. In this class the medals of the Paduan rank highest; the others being so numerous, that a complete series of imperial medals of almost every kind, nay almost of every medallion, may be formed from among them. In France, particularly, by far the greater part of the cabinets are filled with counterfeits of this kind. They are distinguished from such as are genuine by the following marks: 1. The counterfeits are almost universally thinner. 2. They are never worn or damaged. 3. The letters are modern. 4. They are either destitute of varnish entirely, or have a false one, which is easily known by its being black, shining, and greasy, and very easily hurt by the touch of a needle, while the varnish of ancient medals is as hard as the metal itself. Instead of the greasy black varnish above mentioned, indeed, they have sometimes a light green one, spotted with a kind of iron marks, and is composed of sulphur, verdigrise, and vinegar. It may frequently be distinguished by the hairstrokes of the pencil with which it was laid on being visible upon it. 5. The sides are either filed or too much smoothed by art, or bear the marks of a small hammer. 6. The counterfeits are always exactly circular, which is not the case with ancient medals, especially after the time of Trajan.

86 Paduan forgeries how known.

The Paduan forgeries may be distinguished from those of inferior artists by the following marks: 1. The former are seldom thinner than the ancient. 2. They very seldom appear as worn or damaged, but the others very frequently, especially in the reverse, and legend of the reverse, which sometimes, as in forged Othos, appear as half consumed by time. 3. The letters in moulds taken from the antique coins have the rudeness of antiquity. 4. False varnish is commonly light green or black, and shines too much or too little. 5. The sides of forged coins are frequently quite smooth, and undistinguishable from the ancient, though to accomplish this requires but little art. 6. Counterfeit medals are frequently as irregular in their form as the genuine; but the Paduan are generally circular, though false coins have often little pieces cut off, in perfect imitation of the genuine. 7. In cast coins, the letters do not go sharp down into the medal, and have no fixed outline; their minute angles, as well as those of the drapery, are commonly filled up, and have not the sharpness of the genuine kind. Where the letters or figures are faint, the coin is greatly to be suspected.

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87 Letters the principal criterion of medals.

The letters form the great criterion of medals, the ancient being very rude, but the modern otherwise; the reason of which, according to Cellini, is, that the ancients engraved all their matrices with the graver or burin, while the modern forgers strike theirs with a punch.

88 Vico's account of false patina.

According to Vico, the false patina is green, black, russet, brown, gray, and iron colour. The green is made from verdigrise, the black is the smoke of sulphur, the gray is made of chalk steeped in urine, the coin being left for some days in the mixture. The russet is next to the natural, by reason of its being a kind of froth which the fire forces from ancient coins; but when false, it shines too much. To make it they frequently took the large brass coins of the Ptolemies, which were often corroded, and made them red hot in the fire; put the coins upon them, and a fine patina adhered. Our author does not say in what manner the iron-coloured patina was made. "Sometimes (adds he) they take an old defaced coin, covered with real patina, and stamp it anew; but the patina is then too bright in the cavities, and too dull in the protuberances. The trial of brass coins with the tongue is not to be despised; for if modern the patina tastes bitter or pungent, while if ancient it is quite tasteless."

Mr Pinkerton informs us, that all medallions from Julius Cæsar to Adrian are much to be suspected of forgery; the true medals of the first 14 emperors being exceedingly valuable, and to be found only in the cabinets of princes.

89 Medals cast from the Paduan forgeries.

II. The second class of counterfeit medals contains those cast from moulds taken from the Paduan forgeries, and others done by eminent masters. These are sometimes more difficult to be discovered than the former, because in casting them they can give any degree of thickness they please; and, filling the small sandholes with mastic, they retouch the letters with a graver, and cover the whole with varnish. The instructions already given for the former class, however, are also useful for those of the second, with this addition, that medals of this class are generally lighter than the genuine, because fire rarefies the metal in some degree, while that which is struck is rather condensed by the strokes. In gold and silver medals there cannot be any deception of this kind; because these metals admit not of patina, and consequently the varnish betrays the imposition. The marks of the file on the margin of those of the second class are a certain sign of forgery; though these do not always indicate the forgery to be of modern date, because the Romans often filed the edges of coins to accommodate them to the purposes of ornament, as quarter guineas are sometimes

How to distinguish true from counterfeits. times put into the bottom of punch ladles. It is common to imitate the holes of medals made by time by means of aquafortis; but this destroys the sides of a coin more effectually than if it had been eat into naturally. The fraud, however, is not easily distinguished.

90 Medals cast from an antique. III. *Medals cast in moulds from an antique.*—In this mode some forgers, as Beauvais informs us, have been so very careful, that they would melt a common medal of the emperor whom they meant to counterfeit, lest the quality of the metal should betray them. "This (says Mr Pinkerton), has been done in the silver Septimius Severus, with the reverse of a triumphal arch, for which a common coin of the same prince has been melted; and in other instances." Putting medals in the fire or upon hot iron to clease them, gives them an appearance of being cast; for some spots of the metal being softer than the rest will run, which makes this one of the worst methods of cleaning medals.—The directions given for discovering the two former deceptions hold good also in this.

91 Ancient medals retouched. IV. *Ancient Medals retouched and altered.*—This is a class of counterfeits more difficult to be discovered than any other. "The art (says Mr Pinkerton) exerted in this class is astonishing; and a connoisseur is the less apt to suspect it, because the coins themselves are in fact ancient. The acute minds of the Italian artists exerted themselves in this way, when the other forgeries became common and known. With graving-tools they alter the portraits, the reverses, and the inscriptions themselves, in a surprising manner. Of a Claudius struck at Antioch they make an Otho; of a Faustina, a Titiana; of a Julia Severa, a Didia Clara; of a Macrinus, a Pescennius, &c. Give them a Marcus Aurelius, he starts up a Pertinax, by thickening the beard a little, and enlarging the nose. In short, wherever there is the least resemblance in persons, reverses, or legends, an artist may from a trivial medal generate a most scarce and valuable one. This fraud is distinguishable by the false varnish which sometimes masks it; but, above all, by the letters of the legend, which are always altered. Though this be sometimes done with an artifice almost miraculous, yet most commonly the characters straggle, are disunited, and not in a line."

In counterfeits of this kind sometimes the obverse is not touched, but the reverse made hollow, and filled with mastic coloured like the coin, and engraven with such device and legend as was most likely to bring a great price; others are only retouched in some minute parts, by which, however, the value of the coin is much diminished. "Against all these arts (says Mr Pinkerton), severe scrutiny must be made by the purchaser upon the medal itself; and the investigation and opinion of eminent antiquaries had upon its being altered, or genuine as it is issued from the mint."

92 Medals with new devices, or soldered. V. *Medals impressed with new devices, or soldered.*—In the first article of this class the reverses have been totally filed off, and new ones impressed with a die and hammer. This is done by putting the face or obverse, whichever is not touched, upon different folds of pasteboard, afterwards applying the die and striking it with a hammer. The forgery in this class is very easily discovered, as the devices and inscriptions on the counterfeits are known not to exist on true medals: as the Pons Ælius on the reverse of Adrian: the Expeditio Judaica of the same emperor, &c. The difference of fabrication in the face or reverse will be discovered at the first glance by any person of skill.

How to distinguish true from counterfeits.

The soldered medals consist of two halves belonging to different medals, sawed through the middle and then joined with solder. This mode of counterfeiting is common in silver and brass coins. "They will take an Antoninus, for example, and saw off the reverse, then solder to the obverse which they have treated in the same manner. This makes a medal, which, from an unknowing purchaser, will bring a hundred times the price of the two coins, which compose it. When the deceit is used in brass coins, they take care that the metals be of one hue; though indeed some pretenders in this way sometimes solder copper and brass together, which at once reveals the deceit. Medals which have a portrait on each side, and which are generally valuable, are the most liable to a suspicion of this fraud. To a very nice eye the minute ring of solder is always visible; and upon inserting a graver, the fabrication falls into halves."

In the same manner reverses are sometimes soldered to faces not originally belonging to them; as one mentioned by Pere Jobert, of Domitian with an amphitheatre, a reverse of Titus joined to it. Another art is sometimes made use of in this kind of counterfeits, of which there is an instance in the temple of Janus upon Nero's medals; where the middle brass is taken off, and inserted in a cavity made in the middle of a large coin of that prince. In the coins of the lower empire, however, the reverses of medals are sometimes so connected with their obverses, that a suspicion of forgery sometimes occurs without any foundation. They are met with most commonly after the time of Gallienus, when such a number of usurpers arose, that it was difficult to obtain an exact portrait of their features; the coiners had not time, therefore, to strike a medal for these as they could have done for other emperors who reigned longer. Hence, on the reverse of a medal of Marius, who reigned only three days, there is PACATOR ORBIS, which shows that at that time they had reverses ready fabricated, to be applied as occasion might require.

VI. *Plated medals, or those which have clefts.*—It has been already remarked, that many true medals are cracked in tho edges; owing to the repeated strokes of the hammer, and the little degree of ductility which the metal possesses. This the forgers attempt to imitate by a file; but it is easy to distinguish betwixt the natural and artificial cleft by means of a small needle. The natural cleft is wide at the extremity, and appears to have a kind of almost imperceptible filaments; the edges of the crack corresponding with each other in a manner which no art can imitate. 93 Plated medals, &c.

The plated medals which have been forged in ancient times were long supposed to be capable of resisting every effort of modern imitation; but of late years, "some ingenious rogues (says Mr Pinkerton), thought of piercing false medals of silver with a red-hot needle, which gave a blackness to the inside of the coin, and made it appear plated to an injudicious eye. This fraud is easily distinguished by scraping the inside of the metal." It is, however, very difficult to distinguish

distinguish the forgeries of rude money, when not cast; and our author gives no other direction than to consult a skilful medallist. Indeed, notwithstanding all the directions already given, this seems to be a resource which cannot by any means with safety be neglected. A real and practical knowledge of coins "is only to be acquired (says he) by seeing a great number, and comparing the forged with the genuine. It cannot therefore be too much recommended to the young connoisseur, who wishes to acquire some knowledge in this way, to visit all the sales and cabinets he can, and to look upon all ancient medals with a very microscopic eye. By these means only is to be acquired that ready knowledge which enables at first glance to pronounce upon a forgery, however ingenious. Nor let the science of medals be from this concluded to be uncertain; for no knowledge is more certain and immediate, when it is properly studied by examination of the real objects. A man who buys coins, trusting merely to his theoretic perusal of medallic books, will find himself wofully mistaken. He ought to study coins first, where only they can be studied, in themselves. Nor can it be matter of wonder or implication of caprice, that a medallist of skill should at one perception pronounce upon the veracity or falsehood of a medal; for the powers of the human eye, employed in certain lines of science, are amazing. Hence a student can distinguish a book among a thousand similar, and quite alike to every other eye: hence a shepherd can discern, &c.; hence the medallist can say in an instant, 'this is a true coin, and this is a false,' though to other people no distinction be perceptible."

Forgeries of modern coins and medals, Mr Pinkerton observes, are almost as numerous as of the ancient. The satiric coin of Louis XII. PERDAM BABYLONIS NOMEN, is a remarkable instance: the false coin is larger than the true, and bears the date 1512. The rude coins of the middle ages are very easily forged, and forgeries have accordingly become common. Forged coins of Alfred and other early princes of England have appeared, some of which have been done with great art. "The two noted English pennies of Rich. I. says our author, are of this stamp; and yet have imposed upon Messrs Folkes and Snelling, who have published them as genuine in the two best books upon English coins. But they were fabricated by a Mr White of Newgate-street, a noted collector, who contaminated an otherwise fair character by such practices. Such forgeries, though easy, require a skill in the history and coinage of the times, which luckily can hardly fall to the lot of a common Jew or mechanic forger. But the practice is detestable, were no gain proposed: and they who stoop to it must suppose, that to embarrass the path of any science with forgery and futility, implies no infamy. In forgeries of ancient coin, the fiction is perhaps sufficiently atoned for by the vast skill required; and the artist may plausibly allege, that his intention was not to deceive, but to excite his utmost powers, by an attempt to rival the ancient masters. But no possible apology can be made for forging the rude money of more modern times. The crime is certainly greater than that which leads the common coiner to the gallows; inasmuch as it is committed with more ease, and the profit is incomparably larger."

Value.

SECT. VIII. *Of the Value of Medals.*

ALL ancient coins and medals, though equally genuine, are not equally valuable. In medals as well as in every thing else, the scarcity of a coin stamps a value upon it which cannot otherwise be derived from its intrinsic worth. There are four or five degrees of rarity reckoned up; the highest of which is called *unique*. The cause is generally ascribed to the fewness of number thrown off originally, or to their having been called in, and recoined in another form. To the former cause Mr Pinkerton ascribes the scarcity of the copper of Otho and the gold of Pescennius Niger; to the latter that of the coinage of Caligula; "though this last (says he) is not of singular rarity; which shows that even the power of the Roman senate could not annihilate an established money; and that the first cause of rarity, arising from the small quantity originally struck, ought to be regarded as the principal."

96 Causes of the scarcity of medals in ancient cities.

In the ancient cities Mr Pinkerton ascribes the scarcity of coin to the poverty or smallness of the state; but the scarcity of ancient regal and imperial coins arises principally from the shortness of the reign; and sometimes from the superabundance of money before, which rendered it almost unnecessary to coin any money during the reign of the prince. An example of this we have in the scarcity of the shillings of George III. which shows that shortness of reign does not always occasion a scarcity of coin: and thus the coins of Harold II. who did not reign a year, are very numerous, while those of Richard I. who reigned ten, are almost unique.

97 Rare coins sometimes become common, and *vice versa.*

Sometimes the rarest coins lose their value, and become common. This our author ascribes to the high price given for them, which tempts the possessors to bring them to market; but chiefly to the discovering of hoards of them. The former cause took place with Queen Anne's farthings, some of which formerly sold at five guineas; nay, if we could believe the newspapers, one of them was some years ago sold for 960l.; the latter with the coins of Canute, the Danish king of England; which were very rare till a hoard of them was discovered in the Orkneys. As discoveries of this kind, however, produce a temporary plenty, so when they are dispersed the former scarcity returns; while, on the other hand, some of the common coins become rare through the mere circumstance of neglect.

98 Silver coins in what cases most esteemed.

As double the number of copper coins of Greek cities are to be met with that there are of silver, the latter are of consequence much more esteemed: but the reverse is the case with those of the Greek princes. All the Greek civic coins of silver are very rare, excepting those of Athens, Corinth, Messana, Dyrrhachium, Massilia, Syracuse, and some others. Of the Greek monarchic coins, the most rare are the tetradrachms of the kings of Syria, the Ptolemies, the sovereigns of Macedon and Bithynia, excepting those of Alexander the Great and Lysimachus. Those of the kings of Cappadocia are of a small size, and scarce to be met with. Of those of Numidia and Mauritania, the coins of Juba, the father, are common; but those of

Value. of the son, and nephew Ptolemy, scarce. Coins of the kings of Sicily, Parthia, and Judea, are rare; the last very much so. We meet with no coins of the kings of Arabia and Comagene except in brass; those of the kings of Bosphorus are in electrum, and a few in brass, but all of them rare; as are likewise those of Philetenis king of Pergamus, and of the kings of Pontus. In the year 1777, a coin of Mithridates sold for 26l. 5s. Didrachms of all kings and cities are scarce, excepting those of Corinth and her colonies; but the gold coins of Philip of Macedon, Alexander the Great, and Lysimachus, as has already been observed, are common. The silver tetradrachms of all kings bear a very high price. The didrachm of Alexander the Great is one of the scarcest of the smaller Greek silver coins; some of the other princes are not uncommon.

99 Greek copper coins. In most cases the copper money of the Greek monarchs is scarce; but that of Hiero I. of Syracuse is uncommonly plenty, as well as that of several of the Ptolemies.

100 Roman consular coins. The most rare of the consular Roman coins are those restored by Trajan: of the others the gold consular coins are the most rare, and the silver the most common; excepting the coin of Brutus with the cap of liberty, already mentioned, with some others. Some of the Roman imperial coins are very scarce, particularly those of Otho in brass; nor indeed does he occur at all on any coin struck at Rome: but the reason of this may with great probability be supposed to have been the shortness of his reign. His portrait upon the brass coins of Egypt and Antioch is very bad: as well as almost all the other imperial coins of Greek cities. The best likeness is on his gold and silver coins; the latter of which are very common. The Greek and Egyptian coins are all of small or middling sizes, and have reverses of various kinds: those of Antioch have Latin legends, as well as most of the other imperial coins of Antioch. They have no other reverse but the SC in a wreath; excepting in one instance or two of the large and middle brass, where the inscriptions are in Greek. Latin coins of Otho in brass, with figures on the reverse, are certainly false; though in the cabinet of D'Ennery at Paris there was an Otho in middle brass restored by Titus, which was esteemed genuine by connoisseurs.

101 Leaden Roman coins. The leaden coins of Rome are very scarce: Most of them are pieces struck or cast on occasion of the saturnalia; others are tickets for festivals and exhibitions, both private and public. The common tickets for theatres were made of lead, as were the *contorniati*; perpetual tickets, like the English silver tickets for the opera. Leaden medallions are also found below the foundations of pillars and other public buildings, in order to perpetuate the memory of the founders. From the time of Augustus also we find that leaden seals were used. The work of Ticorini upon this subject, entitled *Piombi Antiochi*, is much recommended by Mr Pinkerton.

102 Of coins blundered in the mintage. The Roman coins, which have been blundered in the manner formerly mentioned, are very rare, and undeservedly valued by the connoisseurs. The blunders in the legends of these coins, which in all probability are the mere effects of accident, have been so far mistaken by some medallists, that they have given rise to imaginary emperors who never existed. A coin of Faustina, which has on the reverse SOUSTI. S. C. puzzled all the German antiquaries, till at last Klotz gave it the following facetious interpretation: *Sine omni utilitate sectamini tantas ineptias.*

103 Heptarchic coins of England. The heptarchic coins of England are generally rare, except those called *stycas*, which are very common, as well as those of Burgred king of Mercia. The coins of Alfred which bear his bust are scarce, and his other money much more so. Those of Hardyknute are so rare, that it was even denied that they had an existence; but Mr Pinkerton informs us, that there are three in the British museum, upon all of which the name HARTHCANUT is quite legible. No English coins of King John are to be met with, though there are some Irish ones; and only French coins of Richard I. "Leake (says Mr Pinkerton) made a strange blunder, in ascribing coins of different kings with two faces, and otherwise spoiled in the stamping, to this prince; in which, as usual, he has been followed by a misled number."

104 Scottish coins. Coins of Alexander II. of Scotland are rather scarce, but those of Alexander III. are more plentiful. Those of John Baliol are rare, and none of Edward Baliol are to be found.

Sect. IX. *Of the Purchase of Medals.*

Purchase. MEDALS are to be had at the shops of goldsmiths and silversmiths, with those who deal in curiosities, &c. but in great cities there are professed dealers in them. The best method of purchasing medals, however, is that of buying whole cabinets, which are every year exposed to auction in London. In these the rare medals are sold by themselves: but the common ones are put up in large lots, so that the dealers commonly purchase them. Mr Pinkerton thinks it would be better that medals were sold one by one; because a lot is often valued and purchased for the sake of a single coin; while the others separately would sell for perhaps four times the price of the whole lot. "If any man of common sense and honesty (says Mr Pinkerton), were to take up the trade of selling coins in London, he would make a fortune in a short time. This profitable business is now in the hands of one or two dealers, who ruin their own interest by making an elegant study a trade of knavery and imposition. If they buy 300 coins for 10s. they will ask 3s. for one of the worst of them! nay, sell forged coins as true to the ignorant. The simpletons complain of want of business. A knave is always a fool."

10[5] Price of gold coins of Carthage. The gold coins of Carthage, Cyrene, and Syracuse, are worth about twice their intrinsic value as metal; but the other gold civic coins from 5l. to 30l. each. The only gold coins of Athens certainly known to exist are two lately procured by the king. One of these remains in possession of his majesty, but the other was given by the queen to Dr Hunter. There was another in the British museum, but suspected not to be genuine. Dr Hunter's coin, then, if sold, would bear the highest price that could be expected for a coin.

10[6] Of silver coins. The silver coins of Syracuse, Dyrrhachium, Massilia, Athens, and a few other states, are common; the drachmas and coins of lesser size are worth about five

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five shillings; the didrachms, tetradrachms, &c. from five to ten, according to their size and beauty; the largest, as might naturally be expected, being more valuable than the small ones. The tetradrachms, when of cities whose coins are common, are worth from 7s. 6d. to 1l. 1s.; but it is impossible to put a value upon the rare civic coins; ten guineas have been given for a single one.

Gre cop- er is.

The Greek copper coins are common, and are almost all of that kind called *small brass;* the middle size being scarce, and the largest in the ages prior to the Roman emperors extremely so. The common Greek coins of brass bring from 3d. to 18d. according to their preservation; but when of cities, whose coins are rare, much higher prices are given. "The want of a few cities, however, (says Mr Pinkerton), is not thought to injure a collection; as indeed new names are discovered every dozen of years, so that no assortment can be perfect. To this it is owing that the rarity of the Grecian civic coins is not much attended to."

8 Gol oins of P ip and ex- and

The gold coins of Philip and Alexander the Great being very common, bear but from five to ten shillings above their intrinsic value; but those of the other princes, being rare, sell from 3l. to 30l. each, or even more.

The tetradrachms are the dearest of the silver monarchic money, selling from five to ten shillings; and if very rare, from 3l. to 30l. Half these prices may be obtained for the drachmas, and the other denominations in proportion.

9 Gre cop- per ns mor are tha e sil

The Greek copper coins are for the most part scarcer than the silver, except the Syro-Grecian, which are common, and almost all of the size called small brass. They ought (says Mr Pinkerton), to bear a high price; but the metal and similarity to the copper civic coins, which are common, keep their actual purchase moderate, if the seller is not well instructed, and the buyer able and willing to pay the price of rarity."

The name of weights given to the ancient Roman ases is, according to our author, exceedingly improper; as that people had weights of lead and brass sides, without the least appearance of a portrait upon them. These denote the weight by a certain number of knobs; and have likewise small *fleurettes* engraved upon them. According to Mr Pinkerton, whenever we meet with a piece of metal stamped on both sides with busts and figures, we may lay it down as a certain rule that it is a coin; but when slightly ornamented and marked upon one side only, we may with equal certainty conclude it to be a weight.

o Pri of the anc tRo- ma ses.

The ancient Roman ases are worth from 2s. to 2l. according to the singularity of their devices. Consular gold coins are worth from 1l. to 5l. Pompey with his sons 21l. and the two Bruti 25l. The silver coins are universally worth from a shilling to half a crown, excepting that of the cap of liberty and a few others, which, if genuine, will bring from 10s. to 5l. The consular copper bears an equal price with the silver, but is more rare; the consular silver coins restored by Trajan are worth 20s. each.

With regard to the Roman imperial coins, it is to be observed, that some of those which belong to princes whose coins are numerous, may yet be rendered extremely valuable by uncommon reverses. Mr Pinkerton particularly points out that of Augustus, with the legend C. MARIVS TROGVS, which is worth three guineas, though the silver coins of that prince in general are not worth above a shilling. In like manner, the common gold coins of Trajan are not worth above twenty shillings; while those with *Basilica Ulpia, Forum Trajani, Divi Nerva et Trajanus, Pater, Divi Nerva et Platina Aug. Profectio Aug. Regna Assignata, Rex Parthus*, and some others, bear from three to six pounds. The ticket medals belong to the Roman senate, and are worth from three to ten shillings. The forged coins and medallions of the Paduan sell from one to three shillings each.

Arrangement, &c.

111 Barbaric coins.

Of the coins of other nations, those of Hilderic king of the Vandals are in silver, and worth 10s.; the small brass of Athanaric, 5s.; the gold of Theodoric 2l.; the second brass of Theodahat 5s.; the second brass of Baducta rare, and worth 10s.; the third brass, 3s. The British coins are very rare, and worth from ten shillings to two guineas each, sometimes much more. Medals with unknown characters are always scarce and dear. Saxon pennies of the heptarchy are rare, and worth from ten shillings to *ten pounds*, according to their scarcity and preservation. The coins of the English kings are common; those of Edward the Confessor, in particular; others are rare, and worth from ten shillings to two guineas, while two of Hardyknute are worth no less than ten guineas. The gold medals of Henry, in 1545, and the coronation of Edward, are worth 20l. each: the Mary of Trezzo, 3l.; Simon's head of Thurloe in gold is worth 12l.; his oval medal in gold upon Blake's naval victory at sea is worth 30l.; and his trial piece, if brought to a sale, would, in Mr Pinkerton's opinion, bring a still higher price. The medals of Queen Anne, which are intrinsically worth about two guineas and a half, sell for about 3l. each; the silver, of the size of a crown piece, sell for 10s. and the copper from five to ten shillings. Dassier's copper pieces sell from two to five shillings, and a few bear a higher price.

112 Gold coins of Scotland.

The Scottish gold coins sell higher than the English, but the others are on a par. The shilling of Mary with the bust is rare, and sells for no less than 30l.; the half 3l.; and the royal 5l. 5s. The French testoon of Francis and Mary brings 10l. 10s. and the Scottish one of Mary and Henry would bring 50l. as would also the medal of James IV. The coronation medal of Francis and Mary is worth 20l. Briot's coronation medal sold in 1755 only for two guineas at Dr Mead's sale; but would now bring 20l. if sold according to rarity.

113 English coins struck in Ireland.

The English coins struck in Ireland are of much the same price with those of the native country; but the St Patrick's halfpence and farthings are rather scarce, and the rare crown of white metal is worth 4l. The gun-money of James II. and all other Irish coins are very common.

SECT. X. *Arrangement of Medals, with the Instruction to be derived from them.*

HAVING thus given a full account of every thing in general relative to medals, we must now come to some particulars respecting their arrangement, and the enter-

tainment

Arrangement, &c.

tainment which a medallist may expect from the trouble and expence he is at making a collection.

It has already been observed, that one of the principle uses of medals is the elucidation of ancient history. Hence the arrangement of his medals is the first thing that must occur in the formation of a cabinet. The most ancient medals with which we are acquainted are those of Alexander I. of Macedon, who began to reign about 501 years before Christ. The series ought of consequence to begin with him, and to be succeeded by the medals of Sicily, Caria, Cyprus, Heraclia, and Pontus. Then follow Egypt, Syria, the Cimmerian Bosphorus, Thrace, Bithynia, Parthia, Armenia, Damascus, Cappadocia, Paphlagonia, Pergamus, Galatia, Cilicia, Sparta, Pæonia, Epirus, Illyricum, Gaul, and the Alps, including the space of time from Alexander the Great to the birth of Christ, and which is to be accounted the third medallic series of ancient monarchs. The last series goes down to the fourth century, including some of the monarchs of Thrace, Bosphorus, and Parthia, with those of Comagene, Edessa or Osrhoene, Mauritania, and Judæa. A most distinct series is formed by the Roman emperors, from Julius Cæsar to the destruction of Rome by the Goths; nay, for a much longer period, were it not that towards the latter part of it the coins become so barbarous as to destroy the beauty of the collection. Many series may be formed of modern potentates.

114
Diadem an ancient emblem of sovereign authority.

By means of medals we can with great certainty determine the various ornaments worn by ancient princes as badges of distinction. The Grecian kings have generally the diadem, without any other ornament; and though in general the side of the face is presented to view, yet in some very ancient Greek and Roman consular coins, full faces of excellent workmanship are met with. On several coins also two or three faces are to be seen, and these are always accounted very valuable.

The diadem, which was no more than a ribbon tied round the head with a floating knot behind, adorns all the Grecian princes from first to last, and is almost an infallible mark of sovereign power. In the Roman consular coins it is seen in conjunction with Numa and Ancus, but never afterwards till the time of Licinius, the colleague of Constantine. Dioclesian, indeed, according to Mr Gibbon, first wore the diadem, but his portrait upon coins is never adorned with it. So great an aversion had the Romans to kingly power, that they rather allowed their emperors to assume the radiated crown, the symbol of divinity, than to wear a diadem; but, after the time of Constantine, it becomes common. The radiated crown appears first on the posthumous coins of Augustus as a mark of deification, but in somewhat more than a century became common.

The laurel crown, at first a badge of conquest, was afterwards permitted by the senate to be worn by Julius Cæsar, in order to hide the baldness of his head. From him all the emperors appear with it on their medals, even to our own times. In the lower empire the crown is sometimes held by a hand above the head, as a mark of piety. Besides these, the naval, mural, and civic crowns appear on the medals both of emperors, and other eminent men, to denote their great actions. The laurel crown is also sometimes worn by the Greek princes. The Arsacidæ of Parthia wear a kind of sash round the head, with their hair in rows of curls like a wig. The Armenian kings have the *tiara*, a kind of cap which was esteemed the badge of imperial power in the east. Conical caps are seen on the medals of Xerxes, a petty prince of Armenia, and Juba the father, the former having a diadem around it.

115
Symbols of divinity on the coins of Alexander and his successors.

The impious vanity of Alexander and his successors in assuming divine honours is manifest on their medals, where various symbols of divinity are met with. Some of them have the horn behind their ear, either to denote their strength, or that they were the successors of Alexander, to whom this badge might be applied as the son of Jupiter Ammon. This, however, Mr Pinkerton observes, is the only one of these symbols which certainly denotes an earthly sovereign, it being doubted whether the rest are not all figures of gods.—According to Eckhet, even the horn and diadem belong to Bacchus, who invented the latter to cure his headaches; and, according to the same author, the only monarch who appears on coins with the horn is Lysimachus. We are informed, however, by Plutarch, that Pyrrhus had a crest of goats horns to his helmet; and the goat, we know, was a symbol of Macedon. Perhaps the successors of Alexander wore this badge of the horn in consequence. The helmet likewise frequently appears on the heads of sovereigns, and Constantine I. has helmets of various forms curiously ornamented.

The diadem is worn by most of the Greek queens, by Orodaltis, daughter of Lycomedes, king of Bithynia; and though the Roman empresses never appear with it, yet this is more than compensated by the variety of their headdresses. Sometimes the bust of an empress is supported by a crescent, to imply that she was the moon, as her husband was the sun of the state. The toga, or vail drawn over the face, at first implied that the person was invested with the pontifical office; and accordingly we find it on the busts of Julius Cæsar, while pontifex maximus. It likewise implies the augurship, the augurs having a particular kind of gown called *lana*, with which they covered their heads when observing an omen. In latter times this implies only consecration, and is common in coins of empresses. It is first met with on the coins of Claudius Gothicus as the mark of consecration of an emperor. The *nimbus*, or glory, now appropriated to saints, has been already mentioned. It is as ancient as Augustus, but is not to be met with on many of the imperial medals, even after it began to be appropriated to them. There is a curious coin, which has upon the reverse of the common piece, with the head of Rome, Urbs Roma, in large brass, Constantine I. sitting amid Victories and genii, with a triple crown upon his head for Europe, Asia, and Africa, with the legend Securitas Romæ.

Portraits upon medals

In general only the bust is given upon medals, though sometimes half the body or more; in which latter case the hands often appear with ensigns of majesty in them; such as the globe, said to have been introduced by Augustus as a symbol of universal dominion; the sceptre, sometimes confounded with the consular staff; a roll of parchment, the symbol of legislative

Arrangement, &c. tive power; and an handkerchief, expressive of the power over the public games, where the emperor gave the signal. Some princes hold a thunderbolt, showing that their power on earth was equal to that of Jupiter in heaven, while others hold an image of Victory.

Medals likewise afford a good number of portraits of illustrious men; but they cannot easily be arranged in chronological order, so that a series of them is not to be expected. It is likewise vain to attempt the formation of a series of gods and goddesses to be found on ancient coins. Mr Pinkerton thinks it much better to arrange them under the several cities or kings whose names they bear. A collection of the portraits of illustrious men may likewise be formed from medals of modern date.

117 Reverses of Greek and Roman coins. The reverses of ancient Greek and Roman coins afford an infinite variety of instruction and amusement. They contain figures of deities at full length, with their attributes and symbols, public symbols and diversions, plants, animals, &c. &c. and in short almost every object of nature or art. Some have the portrait of the queen, son, or daughter of the prince whose image appears on the face obverse; and these are esteemed highly by antiquaries, not only because every coin stamped with portraits on both sides is accounted valuable, but because they render it certain that the person represented on the reverse was the wife, son, or daughter of him who appears on the obverse; by which means they assist greatly in the adjusting of a series. Some, however, with two portraits are common, as Augustus, the reverse of Caligula; and Marcus Aurelius, reverse of Antoninus Pius.

We find more art and design in the reverses of the Roman medals than of the Greek; but on the other hand, the latter have more exquisite relief and workmanship. The very ancient coins have no reverses, excepting a rude mark struck into the metal, resembling that of an instrument with four blunt points on which the coin was struck; and was owing to its having been fixed by such an instrument on that side to receive the impression upon the other. To this succeeds the image of a dolphin, or some small animal, in one of the departments of the rude mark, or in a hollow square: and this again is succeeded by a more perfect image, without any mark of the hollow square. Some of the Greek coins are hollow in the reverse, as those of Caulonia, Crotona, Metapontum, and some other ancient cities of Magna Græcia. About 500 B. C. perfect reverses appear on the Greek coins, of exquisite relief and workmanship. "The very muscles of men and animals (says Mr Pinkerton), are seen, and will bear inspection with the largest magnifier as ancient gems. The ancients certainly had not eyes different from ours; and it is clear that they must have magnified objects. A drop of water forms a microscope; and it is probable this was the only one of the ancients. To Greek artists we are indebted for the beauty of the Roman imperial coins; and these are so highly finished, that on some reverses, as that of Nero's decursion, the *adventus* and *progressio* of various emperors, the *fundator pacis* of Severus, the features of the emperor, riding or walking, are as exact as on the obverse. But though the best Greek artists were called to Rome, yet the Greek coins under the Roman emperors are sometimes well executed, and always full of variety and curiosity. No Roman or Etruscan coins have been found of the globular form, or indented on the reverse like the early Greek. The first Greek are small pieces of silver, while the Roman are large masses of copper. The former are struck; the latter cast in moulds. The reverses of the Roman coins are very uniform, the prow of a ship, a car, or the like, till about the year 100 B. C. when various reverses appear on their consular coins in all metals. The variety and beauty of the Roman imperial reverses are well known, The medallist much values those which have a number of figures; as the *Puellæ Faustinianæ*, of Faustina, a gold coin no larger than a sixpence, which has 12 figures; that of Trajan, *regna assignata*, has four; the *congiarium* of Nerva five; the allocution of Trajan seven; of Hadrian 10; of Probus 12. Some Roman medals have small figures on both sides, as the *Apollini sancto* of Julian II. Such have not received any peculiar name among the medallists. Others have only a reverse, as the noted *spintriati*, which have numerals I. II. &c. on the obverse."

118 Of the deities represented upon ancient coins. The *names* of the deities represented on the reverses of Greek coins are never expressed; perhaps, as Mr Pinkerton supposes, out of piety, a symbolical representation of their attributes being all that they thought proper to delineate; but the Roman coins always express the name, frequently with an adjunct, as VENERI VICTRICI, &c. In others, the name of the emperor or empress is added; as PUDICITIÆ AUGUSTÆ, round an image of modesty; VIRTUS AUGUSTI, a legend for an image of virtue.

The principal symbols of the divine attributes to be met with on the Greek medals are as follow:

1. Jupiter is known on the coins of Alexander the Great by his eagle and thunderbolts; but when the figure occurs only on the obverses of coins, he is distinguished by a laurel crown, and placid bearded countenance. Jupiter Ammon is known by the ram's horn twisting round his ear; a symbol of power and strength, assumed by some of the successors of Alexander the Great, particularly by Lysimachus.

2. Neptune is known by his trident, dolphin, or being drawn by sea horses; but he is seldom met with on the Grecian coins.

3. Apollo is distinguished by an harp, branch of laurel, or tripod; and sometimes by a bow and arrows. In the character of the sun, his head is surrounded with rays; but when the bust only occurs, he has a fair young face, and is crowned with laurel. He is frequent on the coins of the Syrian princes.

4. Mars is distinguished by his armour, and sometimes by a trophy on his shoulders. His head is armed with a helmet, and has a ferocious countenance.

5. Mercury is represented as a youth, with a small cap on his head, wings behind his ears and on his feet. He is known by the cap, which resembles a small hat, and the wings. He appears also with the caduceus, or wand twined with serpents, and the *marsupium*, or purse, which he holds in his hand.

6. Æsculapius is known by his bushy beard, and his leaning on a club with a serpent twisted round it. He

Arrangement, &c.

He sometimes occurs with his wife Hygeia or Health, with their son *Telesphorus* or Convalescence between them.

7. Bacchus is known by his crown of ivy or vine, his diadem and horn, with a tyger and satyrs around him.

8. The figure of Hercules is common on the coins of Alexander the Great, and has frequently been mistaken for that of the prince himself. He appears sometimes as a youth and sometimes with a beard. He is known by the club, lion's skin, and remarkable apparent strength; sometimes he has a cup in his hand; and a poplar tree, as a symbol of vigour, is sometimes added to the portrait.

9. The Egyptian Serapis is known by his bushy beard, and a measure upon his head.

10. Apis is delineated in the form of a bull, with a flower of the lotos, the water lily of the Nile, supposed by Macrobius to be a symbol of creation; and Jamblichus tells us, that Osiris was thought to have his throne in it.

11. Harpocrates, the god of Silence, appears with his finger on his mouth; sometimes with the sistrum in his left hand; a symbol common to most of the Egyptian deities.

12. Canopus, another Egyptian deity, appears in the shape of a human head placed on a kind of pitcher. "This deified pitcher (says Mr Pinkerton), seems to refer to an anecdote of ancient superstition, which, I believe, is recorded by Plutarch. It seems some Persian and Egyptian priests had a contest which of their deities had the superiority. The Egyptian said, that a single vase, sacred to Serapis, would extinguish the whole power of the Persian deity of fire. The experiment was tried; and the wily Egyptian, boring holes in the vase and stopping them with wax, afterwards filled the vase with water; which, gushing through the holes as the wax melted, extinguished the Persian deity. Hence the vase was deified."

13. The *Holy Senate* and *Holy People*, appear frequently on the Greek imperial coins, sometimes represented as old men with beards, at others as youths.

The goddesses represented on medals are,

1. Juno, represented by a beautiful young woman, sometimes with a diadem, sometimes without any badge, which is reckoned a sufficient distinction, as the other goddesses all wear badges. Sometimes she appears as the goddess of marriage; and is then veiled to the middle, and sometimes to the toes. She is known by the peacock, a bird sacred to her from the fable of Argus.

2. Minerva is very common on the coins of Alexander the Great; and her bust has been mistaken by the celebrated painter Le Brun for the hero himself. She is very easily distinguished by the helmet. Her symbols are, her armour; the spear in her right hand and the ægis, with a Medusa's head, in her left; an owl commonly standing by her.

3. Diana of Ephesus is commonly represented on the Greek imperial coins; and appears with a great number of breasts, supposed to denote universal Nature. She is supported by two deer, and carries a pannier of fruit upon her head. The bust of this goddess is known by the crescent on her brow, and sometimes by the bow and quiver at her side.

Arrangement, &c.

4. Venus is known by an apple, the prize of beauty, in her hand. Sometimes she is distinguished only by her total want of dress; but is always to be known by her extraordinary beauty, and is sometimes adorned with pearls about the neck.

5. Cupid is sometimes met with on the Syrian coins, and is known by his infancy and wings.

6. Cybele is known by a turreted crown and lion; or is seen in a chariot drawn by lions.

7. Ceres is known by her garland of wheat, and is common on the Sicilian coins; that island being remarkable for its fertility. Sometimes she has two serpents by her, and is sometimes drawn in a chariot by them. She carries in her hands the torches with which she is fabled to have gone in search of her daughter Proserpine.

8. Proserpine herself is sometimes met with on coins, with the name of κορη, or the *girl*.

9. The Egyptian Isis has a bud or flower on her head; a symbol of the perpetual bloom of the inhabitants of heaven. She carries also a sistrum in her hand.

10. The Sidonian Astarte appears on a globe supported on a chariot with two wheels, and drawn by two horses.

These are the deities most commonly represented on the Greek coins. The more uncommon are, Saturn with his scythe, or with a hook on the Heraclian coins; Vulcan with his tongs on the reverse of a coin of Thyatira, represented at work in the presence of Minerva. Adranus, a Sicilian god, is sometimes represented on coins with a dog. Anubis, an Egyptian deity, has a dog's head. Atis is known by his Phrygian bonnet; Castor and Pollux by a star on the head of each; Dis, by his old face, dishevelled hair and beard, and a hook: Flora by her crown of flowers; Nemesis by her wheel; and Pan by his horns and ears belonging to some kind of beast. 119

Table of symbols.

There are likewise to be found on medals many different symbols by themselves; of the most remarkable of which we shall give the following table, with their signification:

Symbols.	*Significations.*
1. Vases with sprigs, -	Solemn games.
2. Small chest or hamper, with a serpent leaping out,	Mystic rites of Bacchus.
3. Anchor on Seleucian medals,	Coin struck at Antioch, where an anchor was dug up.
4. Apollo on Syrian coins, on an inverted hamper,	Covered tripod.
5. Bee, - - -	Aristeus the son of Apollo.
6. Laurel, - - -	Apollo.
7. Reed, - - -	A river.
8. Ivy and grapes, - -	Bacchus.
9. Poppy, - - -	Ceres and Proserpine.
10. Corn, - - -	Ceres.
11. Owl and olive, - -	Minerva.
12. Dove, - - -	Venus.

13.

Symbols.	Significations.
13. Torch, - - - -	Diana, Ceres, or Proserpine.
14. Mudnis, or conic stone, -	The sun, Belus, or Venus.
Symbols of Countries, &c.	
15. Pomegranate flowers, -	Rhodes.
16. Owl, - -	Athens.
17. Pegasus, - -	Corinth.
18. Wolf's head, - -	Argos.
19. Bull's head, - -	Bœotia.
20. Minotaur's head and labyrinth,	Crete.
21. Horse's head, - -	Pharsalia.
22. Lion, - - -	Marseilles.
23. Tortoise, - - -	Peloponnesus.
24. Sphinx, - -	Scio.
25. Three legs joined as in the Isle of Man money, - -	Sicily.
26. Horse, - - -	Thessaly.
27. The crescent, - -	Byzantium (A)
28. Bull, - - -	Supposed to be a river.
29. Ensign, with the letters COL.	A colony drawn from one legion.
30. Bull, - - . -	Apis, strength or security.
31. Caduceus, - - -	Peace and concord.
32. Cornucopiæ, - -	Abundance.
33. Pontifical hat, - -	Priesthood.
34. Parazonium, - -	Batoon of command.
35. Globe on an altar with three stars, - - - -	The world preserved by the gods for the three sons of Constant. I.
36. Fort and gate, -	Security.
37. Tribuli, a kind of chevaux de frize, - - -	Unknown.
38. Altar or tripod, - -	Piety.
39. Dolphin, - - -	Apollo.
40. Lectisternia, - -	Festivals.
41. Lituus, or twisted wand, -	Augurship.
42. Apex, or cap with strings,	Pontificate.
43. Thensa, or chariot employed to carry images, - -	Consecration of an empress.
44. Peacock, - - -	Ditto.
45. Eagle, - - -	Consecration of an emperor.

Arrangement, &c.

120 *Legends of medals.*

The legends put upon medals are designed as explanations of them; but as the compass of even the largest coins does not admit of any great length of inscription, it has always been found necessary to use abbreviations; and in readily decyphering these lies a considerable part of the difficulty of the science. This, however, is greater in the Roman than in the Greek medals; for the Greeks commonly insert as much of the word as is sufficient to enable us easily to understand its meaning; but it is common for those who attempt to explain letters that do not often occur, to fall into very ridiculous errors. Of this Mr Pinkerton gives a most remarkable instance in Fortunius Licetus, a learned man, who finding upon a coin of Adrian the letters, Γ. ΙΔ signifying the 14th year of that emperor's reign, imagined that they signified *Lucernas invenit Delta;* "Delta invented lanthorns;" and thence ascribed the origin of lanthorns to the Egyptians. Tables explaining the meaning of the abbreviations found upon medals have been published by Patin, Ursatus, and others.

121 *Extraordinary mistake of Fortunius Licetus.*

SECT. XI. *Of Medallions, Medalets*, &c.

BESIDES the ordinary coins of the ancients, which passed in common circulation through the country, there were others of a larger size, which are now termed *medallions*. These were struck on the commencement of the reign of a new emperor and other solemn occasions: frequently also, by the Greeks in particular, as monuments of gratitude or of flattery. Sometimes they were mere trial or pattern pieces; and those abound after the time of Maximian, with the words *Tres Monetæ* on the reverse. The common opinion is, that all the Roman pieces of gold exceeding the denarius aureus, all in silver exceeding the denarius, and all in brass exceeding the sestertius, went under the denomination of *medallions:* but Mr Pinkerton thinks that many of these large pieces went in circulation, though not very commonly, as our five and two guinea pieces, silver crowns, &c. do in this country. The finest medallions were presented by the mint-masters to the emperor, and by the emperor to his friends, as specimens of fine workmanship. The best we have at present are of brass, and many of them composed of two sorts of metal; the centre being copper, with a ring of brass around it, or the contrary; and the inscription is sometimes confined to one of the metals, sometimes not. There is a remarkable difference between the Greek and Roman medallions in point of thickness; the latter being frequently three or four lines thick, while the other seldom exceed one. Very few medallions, however, were struck by the Greeks before the time of the Roman emperors; but the Greek medallions of the emperors are more numerous than those

(A) This appears on the early coins of Byzantium, with the legend ΒΥΖΑΝΤΙΝ. ΣΩΤ. "the preserver of Byzantium." The reason of this was, that when Philip of Macedon besieged the city, and was about to storm it in a cloudy night, the moon shone out on a sudden and discovered him; by which means the inhabitants had time to collect their forces and repulse him. The Turks on entering Constantinople, found this badge in many places; and suspecting some magical power in it, assumed the symbol, and its power, to themselves; so that the crescent is now the chief Turkish ensign.

Medallions, &c. those of the Romans themselves. And all these pieces, however, are of such high price that few private persons are able to purchase them. In the last century Christina queen of Sweden procured about 300. In the king of France's collection there are 1200; a number formerly supposed not to exist; and Dr Hunter's collection contains about 400, exclusive of the Egyptian.

Besides these large pieces, there are smaller ones, of a size somewhat larger than our half-crowns; and by Italian medallists are called *medaglion cini*, or small medallions. They are still scarcer than the large kind.

122 Of medalets. There is still a third kind, which have almost escaped the notice of medallists, viz. the small coins or *missilia* scattered among the people on solemn occasions; such as those struck for the slaves on account of the saturnalia; counters for gaming; tickets for baths and feasts; tokens in copper and in lead, &c. These are distinguished by Mr Pinkerton by the name of *medalets*. Many, or perhaps almost all, of those struck for the saturnalia were satirical; as the slaves had then a license to ridicule not only their masters but any person whatever. Mr Pinkerton mentions one of the most common pieces of this kind, which has on the obverse the head of an old woman veiled, with a laurel crown; the reverse only S. C. within a wreath. Baudelot is of opinion that it is the head of Acca Laurentia, the nurse of Romulus, to whom a festival was ordained. "Perhaps (says Mr Pinkerton), it was struck in ridicule of Julius Cæsar; for the manner of the laurel crown, and its high appearance over the head, perfectly resemble that of Julius on his coins." Some have a ship upon one side; on the reverse T, or a cross, which was the image of Priapus; and occasioned many false invectives against the first Christians, who paid such respect to the cross. Some pieces have the heads of the emperors upon one side, on the reverse only numerals, III. IV. V. &c., and the noted *spintriati* of Tacitus. Both these kinds appear tickets for the baths, as the number seems to denote the particular bath. Some have the head of a girl with a vessel used at the baths in her hand. The spintriati are so immodest, that few will bear mention. But some are merely ludicrous; as one which has an ass with a bell about his neck, and a soldier riding him; another with two figures hoisting a woman in a basket into the air. Of those that will just bear mention, is a man with titles around him, as chief of the games; and a woman in ridicule of the modest bath-girl above mentioned. There is also one marked XIX, on which appears an imperator triumphing in a car: this car is placed on the back of a camel; and behind the imperator is a monkey mimicking him.

123 Of the contorniati. A fourth class of medals are called *contorniati* from the Italian *contorniato*, "encircled;" because of the hollow circle which commonly runs around them. They are distinguished from medallions by their thinness, faint relief, reverses sometimes in relief, sometimes hollow; and in general by the inferiority in their workmanship. The opinions of medallists concerning these pieces are very various; some suppose them to have been struck by Gallienus to the memory of illustrious men and celebrated *athletæ* at the time that he caused all the consecration coins of his predecessors to be restored; others ascribe their invention to Greece, &c. but Mr Pinkerton is of opinion that they were only tickets for places at public games. Many of them, notwithstanding their inferior workmanship, are very valuable on account of their preserving the portraits of some illustrious authors of antiquity, nowhere else to be found. Much dependance, however, cannot be put on the portraits of Greek authors and eminent men found upon some of them; for though we know that the busts of Sallust, Horace, &c. must have been struck when their persons were fresh in the memory of the artists, yet it was otherwise with Homer, Solon, Pythagoras, &c. which are to be found on some of them. Even these, however, are valuable, as being ancient and perhaps traditional portraits of these great men. The last whose portraits are supposed to have been delineated in this way, are Apollonius Tyaneus who flourished in the time of Domitian, and Apuleius in that of Marcus Antoninus. Mr Pinkerton thinks it a confirmation of his opinion concerning these medals, that the reverses always contain some device alluding to public games, as that of a charioteer driving a chariot, &c.

Sect. XII. *Directions for making Cabinets.*

We must now proceed to the last part of our subject, viz. that of giving directions for the formation of cabinets. As we have already seen that the formation of any one must be attended with very considerable expence, it is necessary for every one who attempts this to proportion the cabinet to his own circumstances. There are, properly speaking, three kinds of cabinets. 1. Those meant to contain a coin of every sort that has been issued from the mint in every age and country; but this, which may be called the large and complete cabinet, is not to be purchased by private persons. That of Dr Hunter already mentioned is perhaps one of the best private cabinets ever known; aud cost 23,000l. but as many duplicates were sold as cost 2000l. by which means the expence was reduced to 21,000l. The vast collection made by the king of France cost upwards of 100,000l. 2. The smaller cabinet may be supposed to consist only of middle and small Roman brass, English pennies, groats, &c. with a few medals of the more valuable kind, and may be supposed to incur an expence of from 20l. to 100l. 3. The smallest kind is called a *casket* of medals, and does not consist of above 1000 at most of various kinds; and consequently the expence must depend on the pleasure of the proprietor.

In the formation of the grand cabinet, it must be observed that the Greek medals of every denomination do not admit of any arrangement by the metals like the Roman; not any regular series of this kind being met with even in the most opulent cabinets. Hence in all collections the civic coins are ranged according to an alphabetical order; and the monarchic in a chronological one. The same rule is to be observed in the Roman consular medals; they are ranged, like the coins of the Greek cities, in an alphabetical series of the families. The Roman imperial coins are

only

Directions for making Cabinets.

only those capable of being arranged according to sizes and metals. Even from this must be excepted the minimi, or very smallest coins; which are so scarce, that the only regular series of them in the world is that belonging to the king of Spain, which was formed by a most skilful French medallist, and consists of all the metals. The arrangement of a grand cabinet, according to Mr Pinkerton, is as follows.

"I. The coins of cities and of free states in alphabetical order: whether using Greek, Roman, Punic, Etruscan, or Spanish characters.

"II. Kings in chronological series, both as to foundation of empire and seniority of reign.

"III. Heroes, heroines, founders of empires, and cities.

"IV. Other illustrious persons.

"V. Roman ases.

"VI. Coins of families, commonly called consular.

"VII. Imperial medallions.

"VIII. Imperial gold.

"IX. Imperial *minimi* of all metals.

"X. Imperial silver.

"XI. Imperial first brass.

"XII. Second brass.

"XIII. Third brass.

"XIV. Colonial coins which are all of brass.

"XV. Greek cities under the emperors, of all metals and sizes. In a smaller cabinet they may be put with the Roman, according to their metal and size. Those without the emperor's head go to Class I. though struck in Roman times.

"XVI. Egyptian coins struck under the Roman emperors, of all metals and sizes. They are mostly of a base metal called by the French *patin;* it is a kind of pot-metal or brittle brass.

"XVII. Contorniati, or ticket medals.

"XVIII. Coins of Gothic princes, &c. inscribed with Roman characters.

"XIX. Coins of southern nations using uncommon alphabets; as the Persian, Punic, Etruscan, and Spanish.

"XX. Coins of northern nations using uncommon characters; as the Runic and German.

"In the modern part no series can be formed of copper that will go back above two centuries; but sequences (chronological series) of gold and silver may be arranged of all the different empires, kingdoms, and states, as far as their several coinages will allow. Those of England and France will be the most perfect. Modern silver is commonly arranged in three sequences; the dollar, the groat, and the penny sizes. The medals of each modern country ought of course to be separated; though it is best to arrange each set in chronological order, let their size of metal be what they will. It may be remarked here, that our modern medals of the size of a tea-saucer, are only so many monuments of barbarism. The ancient medallions are almost universally but little larger than our crown-piece, though three or four of them may extend to about two inches diameter, but very many modern medals to four inches and more. A large medal always declares an ignorant prince or an ignorant artist. Into the size of a crown-piece the ancients threw more miracles in this way than will ever appear in these monstrous productions."

These directions will likewise apply to the formation of a cabinet of the second kind: but if the collector means to form a series of large Roman brass, he will find the coins of four or five emperors so scarce as not to be attainable in that series, even at any price. He must therefore supply their places with middle brass, as is allowed with regard to Otho, even in the best cabinets; there not being above three coins of that emperor in large brass known in the world: whereas of the middle brass, two or three hundred may exist. For this reason Mr Pinkerton concludes, that in cabinets of the second class, the collector may mingle the large and second brass together as he thinks proper, in order to save expence; though it would not do so well to unite such disproportionate sizes as the large and small. "In the small sequence, however (says he), there can be no harm in his mixing gold, silver, and brass, as chance or curiosity may lead him to purchase any of these metals. And though your starched bigotted medallist may sneer because such a sequence would controvert his formal and narrow way of thinking, common sense will authorize us to laugh at the pedant in our turn, and to pronounce such a series more various, rich, and interesting, than if the collector had arranged only one metal, and rejected a curious article because he did not collect gold or silver. In like manner, if, in the modern part of the smaller cabinet, any coin of a series is of high price, or of bad impression, there can be no impropriety in putting another of the same reign, which is cheaper, or better executed, though of a different denomination or of a little larger size. In short, the collector has no rules but in the Greek cities and Roman families, to observe alphabetical order and chronology in every thing else."

Ancient Coins.

TABLES of Ancient Coins.

The most ancient coins, according to Froelich, are distinguished by the following marks, which he accounts infallible. 1. Their oval circumference, and globulous swelling shape. 2. Antiquity of alphabet. 3. The characters being retrograde, or the first divisions of the legend in the common style, while the next is retrograde. 4. The indented square already described. 5. The simple structure of the mintage. 6. Some of the very old coins are hollowed on the reverse, with the image impressed on the front. 7. The dress, symbols, &c. frequently of the rudest design and execution.

TABLE I. *Ancient Greek Coins.*

1. Those without impression.

2. With one or more hollow indented marks on one side, and an impression in relief on the other.—Of Chalcedon on the Hellespont, Lesbos, Abdera in Thrace, Acanthus in Macedon, those said to belong to Egium in Achaia. This class continues from about 900 to 700 B. C.

3. With an indented square divided into segments, having a small figure in one of them; the rest blank, with a figure in relief on the obverse.—Of Syracuse and other places adjacent.—Continue from 700 to 600 B. C.

4. Coins

Ancient Coins.

4. Coins hollow on the reverse, with figures in relief on the obverse.—Of Caulonia, Crotona, Metapontum, &c. Supposed by some to be a local coinage of Magna Græcia; but probably of equal antiquity with the former.

5. Coins in which a square die is used on one or both sides.—Of Athens, Cyrene, Argos, &c.—Of Alexander I. and Archelaus I. of Macedon. Disused in the reign of the latter about 420 B. C.

6. Complete coins, both in obverse and reverse, occur first in Sicily in the time of Gelo, about 491 B. C.

7. Coins of Alexander the Great and his successors. About the time of this hero the Greek coins began to attain to perfection, and were struck of uncommon beauty. It is remarkable, that on the coins of this monarch his own image seldom occurs. The only one yet found of Alexander with his portrait upon it, and struck during his reign, is a silver hemidrachm in Dr Hunter's cabinet, which is represented Plate CCCXXXI. N° 3. After his death many coins bear his portrait. Trebellius Pollio informs us, that some coins, particularly those of Alexander, used to be worn as amulets; and many medals are met with in cabinets, bored seemingly with that intention.

8. Coins of the Successors of Alexander.—Those of the Syrian monarchs almost equal the coins of Alexander himself in beauty. Those of Antiochus VI. are supposed to be the most perfect patterns of male beauty to be met with any where. The Egyptian Ptolemies are somewhat inferior.

9. The coins of the Arsacidæ of Parthia done by Greek workmen.

10. The Greek imperial coins, being such as have the head of the emperor or empress: such as have not these impressions being classed with the civic coins, though struck under the Roman power. None of the imperial coins occur in gold. Of silver there are those of Antioch, Tyre, Sidon, Tarsus, Berytus, Cæsarea, Egyptian silver coins of base metal, Syrian silver coins, which sometimes bear on the reverse the club of Hercules, or the Tyrian shell-fish. Those of Sidon bear the image of the goddess Astarte, or her chariot. Those of Cæsarea in Cappadocia of better work than the Syrian. Lycian coins of good workmanship: on the reverse two harps and an owl sitting upon them. Silver coins of Gelon in Sarmatia resembling the Syrian. The situation of this town is very much unknown. It seems to have been situated on the north of the Euxine sea, where some Sarmatic or Sclavonic tribes were mingled with the Scythians or Goths. The Greek imperial brass coins are very numerous. A series of almost all the emperors may be had from those of Antioch, with a Latin legend on the obverse and Greek on the reverse. Those of Bithynia and Phrygia remarkable for good workmanship. The coins of Tarsus remarkable for their curious views of objects, almost in perspective. The Egyptian coins, from the time of Augustus to Nero, are worse executed than afterwards. From Nero to Commodus they are frequently of admirable workmanship, and in a peculiar style, distinct both from the Greek and Roman. From the time of Commodus they decline, and are lost after the reign of Constantius I. The Egyptian brass coins of the Roman period are likewise of excellent workmanship, especially in the time of Antoninus Pius.

Ancient Coins.

TABLE II. *Roman Coins.*

I. The consular coins, called also the coins of families, and arranged alphabetically in cabinets, according to the names of the families which appear on them. They are,

1. *Brass Coins.*—These consist chiefly of large pieces of rude workmanship without any interesting imagery. In cabinets they are generally kept in boxes apart by themselves. The as bears the head of Janus; the semis of Jupiter with S; the triens of Minerva with four cyphers; the quadrans of Hercules with three cyphers; the sextans of Mercury with two cyphers; and the uncia bears the head of Rome with one cypher. In all these pieces the prow of a ship is constantly the figure on the reverse, with very few exceptions. Sometimes indeed they have a shell, two heads of barley, a frog, an anchor or a dog, on the reverse. About the time of Julius Cæsar both the obverses and the reverses of the coins began to be altered.

2. *Silver.*—Of this the denarius was the first and principal coin. It was stamped originally with X, denoting that the value was ten ases. On the reverse was Castor and Pollux, or a chariot of Victory. Afterwards the busts of various deities make their appearance; and in the seventh century of Rome the portraits of illustrious persons deceased are met with: but till the time of Julius Cæsar no figure of any living person is to be met with; Julius himself being the first who assumed that honour. The workmanship on the best and worst silver is much the same. The reverses are very curious, and point out many remarkable events in Roman history; but none of these occur till about a century before the Christian era. The large denarii, with ROMA, are the most ancient; and some of these bear the Pelasgic A, not the Roman. The silver sestertii have a head of Mercury, with a caduceus on the reverse. The quinarii have always a head of Jupiter, with a Victory on the reverse.

3. *Gold.*—Most of these are of great value. The number of these exceeds not 100; those of brass 200; and of silver 2000. The aureus is the general gold coin; but two or three gold semisses of families likewise occur.

II. Roman imperial coins.

1. *Brass.*—This is of three sizes; large, middle, and small. The first forms a most beautiful series, but very expensive. The various colours of the patina have the finest effect. It is the most important of all the Roman coins, and exceeds even the gold in value.

The middle brass is next in value to the former; and in it are many rare and curious coins, particularly interesting to Britons, as elucidating the history of the island. Of these are the triumphal arch of Claudius; the EXERC. BRITANNICUS of Adrian; the coins of Antoninus Pius, Commodus, Severus, with a Victory, VICTORIA BRITAN.: but especially those personifying the country BRITANNIA. "The number of Roman coins relating to Britain (says Mr Pinkerton) is remarkable, more than 20 having been struck at various times: while those personifying Italy, Gaul, Spain,

Spain, and other regions of the empire, exceed not four or six at most for each country." Only one country vies with Britain, and that is Dacia on the extreme north-east of the empire, as Britain on the extreme north-west. No doubt this circumstance of remoteness in these two countries recommended them to this particular attention, as more expressive of the Roman power.

The small brass series abounds also with curious coins. They are scarce till the time of Valerian and Gallienus, but very common afterwards. Mr Pinkerton recommends, therefore, to form a series in silver as well as brass; both being the cheapest of all the Roman coins. "In this series (says he), it is a common fault to arrange many coins which have been plated with gold or silver, the forgeries of ancient times, but which time has worn off either wholly or in part." All real brass coins have the S. C. till the time of Gallienus; as the senate alone had the power of striking brass, while the emperor himself had that of gold and silver. When the S. C. therefore, is wanting, the coin was certainly once plated; as, in general, the different type and fabric, being those of gold and silver, sufficiently show themselves. With Pertinax, A. D. 192, there is a temporary cessation of small brass; nor after him do any princes occur in that series till Valerian, A. D. 254, excepting Trajanus Decius, A. D. 250 only. After Valerian the series is continuous and common. The brass coinage gradually declined in size from the time of Severus; so that parts of the as could not be struck, or at least it was held unnecessary to strike them. Trajanus Decius attempted in vain to restore the coinage; and Valerian and Gallienus were forced to issue denarii ærei and small assaria. The series of large and of middle brass are of two fixed and known sizes; the former about that of our crown, the latter of the half crown: though after Severus they gradually lessen. But the small brass takes in all parts of the as; and every brass coin not larger than our shilling belongs to this series. The *minimi*, indeed, or very smallest, it is proper to keep apart. The coins of Julius Cæsar in this size are of peculiarly fine workmanship. They bear his portrait reverse of Augustus, or the reverse has a crocodile EGYPTO CAPTA. There are several with Mark Antony, and some with Cleopatra; but the more common pieces are those with only numerals on the obverse, which go the length of XIII.; probably tickets for the baths. A great many occur in the time of Nero; of which Mr Pinkerton particularizes one which has "on the reverse a table ornamented with griffins and other devices. Upon it is placed a wreath of laurel and a beautiful vase, of which the embossed human figures are so minute, and finished so surprisingly, as to stamp these coins the most exquisite productions of the ancient mint." From the time of Nero to that of Vespasian no small brass occurs: but there are many of this emperor, and of his son Titus; while Domitian has as many as Nero, and Domitia his wife has almost as many. Succeeding emperors to the time of Pertinax have also many brass coins; but from his time to that of Valerian there are no real small brass excepting those of Trajanus Decius. After Gallienus there are a great many coins of this kind; and Mr Pinkerton mentions one in Dr Hunter's cabinet, of an unknown person named Nigrianus. The coin seems to have been struck at Carthage; and our author concludes that he was an African usurper, father to Nigrianus.

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2. *Silver*.—This series is very complete, and the cheapest of any; especially as the small brass becomes a fine supplement to it: the latter being had in plenty when the silver becomes scarce, and the silver being plentiful when the brass is scarce.

3. *Gold*.—The Roman imperial gold coins form a series of great beauty and perfection; but on account of their great price, are beyond the purchase of private persons.

4. *The colonial coins* occur only in brass; none, excepting that of Nemausus, having a right to coin silver. They begin in Spain with Julius Cæsar and Antony, and cease with Caligula, who took away the privilege of coinage from the Spanish colonies. The most beautiful are those of Corinth. The other remarkable colonial coins are those of Emerita, Ilice, Terraco, Cassandria, Babba, Berytus, Cæsarea, Patræ, Emisa, Heliopolis or Balbec, Ptolemais, Sidon, Tyre, Deulten, Dium, Troas, Rhesaina, Neapolis of Samaria, which bears a representation of Mount Gerizzim with the temple on it, Hippo in Africa, &c. On many of these coins we meet with fine representations of temples, triumphal arches, gods, goddesses, and illustrious persons. But coins with those representations are by no means common; the colonial coins till the time of Trajan bearing only a plough, or some other simple badge of a colony. Camelodunum is the only colony in Britain of which we have any coins.

5. The *minimi*.—This includes the smallest coins of all denominations, most of which do not exceed the size of a silver penny. They are the most curious of all; but no series of them was ever formed by any person except the abbe Rothelin, whose collection, formed of all metals, passed to the queen of Spain. The reason of the scarcity of these small coins is probably their diminutive size; by reason of which they are mostly lost.

It is surprising that numbers of Roman coins are found through all countries once subject to that powerful people. Some have been met with in the Orkneys, and many in the most remote parts of Europe, Asia, and Africa, known to the ancients.

TABLE III. *Coins of other Ancient Nations.*

1. The Lydians appear to have invented coinage; though, perhaps, this honour may be disputed with them by the Greeks.

2. The Assyrians, Medes, Babylonians, Phœnicians, and Egyptians, had no coins. In the mouths of the mummies, are only thin, unstamped, and round pieces of gold, to pay Charon's fare.

3. No Indian or Chinese coins are to be met with till a very late period; and even then so rude as scarce to be worth notice. Voltaire mentions a collection of ancient Chinese and Indian coins made by the emperor of China in 1700; but Mr Pinkerton supposes it to have consisted only of the Greek and Roman money which had been introduced into these countries.

4. The Lydian coins have no legends; so that mere conjecture only determines the ancient coins of electrum

and

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and silver found in Asia, and different from the Persian, to belong to Lydia. Crœsus coined gold into a form which he called *staters;* and Mr Pinkerton mentions a very ancient gold coin in Dr Hunter's cabinet, which he supposes to have been one of these. It has a globous figure, with indented marks on one side, and on the other a man kneeling, with a fish held out in the left hand, and a sword depending in the right. It weighs four drachms; which Josephus tells us was the weight of the Lydian gold coins. In the same collection are other gold coins little inferior in antiquity; the most ancient of which, our author supposes, may have been coined by the cities of Asia Minor, as coinage passed through them to Greece. They are of admirable workmanship, and as much superior to the best Sicilian coins, as the latter are to all the rest in the world. These gold coins are all extremely pale; owing to the want of knowledge in refining gold.

5. Persian coins.—These were first struck by Darius Hystaspes, whence they had the name of *darics.* They are of gold, and generally have the figure of an archer: they weigh about four drachms; and some occur with the indented mark on one side, while others have figures upon both. The silver coins have generally a king in a chariot of two horses, with a charioteer, and sometimes another figure on foot behind, on the obverse: while the reverse presents a ship, sometimes a ram, bull, or other animal. The gold coins, which only had the title of *darics,* are extremely scarce, having been melted down, as is supposed, and recoined by Alexander the Great on his conquest of Asia.

There is a second series of Persian coins beginning with Artaxares, or Artaxerxes, who overthrew the Parthian monarchy about the year 210. These are large and thin, with the king's bust on one side, and the altar of Mithras on the other; generally with a human figure on each side. These coins continue till the year 636, when Persia was conquered by the Saracens. These have only Persian letters upon them, which have never been explained by any antiquaries. Mr Pinkerton says that they seem to partake of the ancient Greek, Gothic, and Alanic.

6. The Hebrew shekels, originally didrachms, but after the times of the Maccabees tetradrachms, are almost all forgeries of modern Jews, as well as the brass coins with Samaritan characters upon them. They have all a sprig upon one side and a vase on the other. Mr Pinkerton says, that the admission of one of them into a cabinet would almost be a disgrace to it.

7. Phœnician and Punic coins are very interesting on account of the great power and wealth of these nations. The alphabets have been cleared by their relation to the Hebrew and Syriac languages.

8. The coins of Palmyra come under the same denomination with the former, Palmyra being a Syrian city.

9. The Etruscan coins have the characters of that nation, which have been explained by their affinity to the Pelasgic, or oldest Greek and Latin.

10. The Spanish coins are inscribed with two or three alphabets allied to the old Greek or Punic; but the inscriptions have not been sufficiently explained.

11. Gaulish coins.—These are numerous, but the most ancient have no legends; and even after the Greek letters were introduced into Gaul by a colony at Marseilles, the legends are very difficult to be explained.

12. British coins.—From a passage in Cæsar's Commentaries, it has been inferred that the Britons used some kind of coins even in his time. Mr Pinkerton informs us, that some rude coins of copper very much mingled with tin are frequently found in England; which, he supposes, may be some of the ancient British money. They are of the size of a didrachm, the common form of the nummus aureus among the ancients. After the time of Cæsar, coinage increased among the Britons; and there are many found of Cunobelinus mentioned in the Roman history. Most of these have on one side CUNO, with an ear of wheat, a horse, a kind of head of Janus, or other symbol; and have frequently also the letters CAMU; supposed to mean Camelodunum. Sometimes the word TASCIA occurs; the meaning of which has not yet been explained.

13. Gothic coins of France, Italy, and Spain, to the time of Charles the Great. These have the Roman characters upon them. The Italian coins are mostly of the size of small brass; and in this way we meet with coins of Athalaric, Theodahat, Witigez, and other Gothic princes. Many others occur, the inscriptions of which, though meant for Roman, are so perverted as to be illegible.

TABLE IV. *Modern Coins.*

Modern Coins.

1. Of Japan.—These are thin plates of gold and silver, of an oval figure, with small marks or figures stamped on them.

2. China.—These are only copper, about the size of a farthing, with a square hole in the middle to put them on strings. The inscriptions on them do not express the name of the sovereign, but the year of his reign; as the *happy year,* the *illustrious year,* &c.

3. The Tartarian coins are rude, having only inscriptions upon them; and they are all posterior to the time of Jenghiz khan.

4. Coins of Thibet, Pegu, and Siam, are much the same, presenting only inscriptions without any figures. They are also of late date.

5. India.—Some old coins have been found in the neighbourhood of Calcutta, of gold, silver, copper, and tin, all mixed together. These have commonly a warrior with a sword on one side, and an Indian female idol on the other, of the same form with the celebrated sculptures in the island of Elephanta; but it is impossible to tell what antiquity they are of. The modern coins are the pagoda of gold, worth little more than six shillings; the roupee of silver upwards of two shillings; and the cash, of copper. There is a remarkable set of roupees, which show the twelve signs; a lion on one, a bull on another, &c. but the occasion on which they were struck is unknown. The other coins of India have generally Persian inscriptions upon them.

6. Persia.—The Persic coins since its conquest by the Arabs continue on the Arabian model.

7. Arabia.—Some coins of the petty princes of Arabia are met with as old as the imperial ages of Rome; but till the time of Haroun Alrashid, no regular

gular coinage appears in the vast empire of the Saracens. Even then the reverse has only an inscription, and the obverse is copied from any Greek or Syrian coin which happened to fall in the moneyer's way. The later Arabian coins are mostly silver, with the name and titles of the prince on one side, and some inscription from the Koran on the other. The more modern coins of this country are in the shape of a fish-hook, with Arabic inscriptions.

8. Turkey.—No regular coinage was formed by the Turks till they became masters of Constantinople. They resemble those of Persia and Arabia, having merely inscriptions on both sides.

9. The coins of the African states, at least such as profess the Mohammedan religion, have merely inscriptions without any figures; those of the internal parts are unknown; and no coinage was used among the Mexicans and Peruvians, the only civilized nations in America; but La Hontan mentions an American savage who had a square medal of copper depending from his neck. Mr Pinkerton supposes it to have come from Japan.

10. Modern Italic coins. Besides the Gothic princes mentioned in the former table, the exarchs of Ravenna coined money with the inscription FELIX RAVENNA, &c. The Lombards issued no coins, but there are some still extant of Charlemagne. The following list shows the origin of the coinage in various Italian states.

Rome.—Papal coinage originates with Hadrian I. Size of silver pennies, with the Pope's name on one side, and SCOS PETRUS on the other. No coins appear from 975 to 1099, excepting of Leo IX. In 1303 appear pennies of the senate and people of Rome, with Peter on the one side and Paul on the other. There are groats of Clement V. with his portrait three quarters length; but the side-head begins with Sixtus V. in 1470. Gold was first coined by John XXII. in 1316. The coins of Alexander VI. Julius II. and Leo X. are remarkable for beauty and elegance.

Milan. Coinage began with Charlemagne. The first coin of the family of Visconti occurs in 1330, under Azo. The set finishes with Louis XII.

Naples. Coinage begins in 840 and 880, with Duke Sergius and Bishop Athanasius. The next coins are of Roger of Sicily, and Roger II. in 1130, William I. II. and Tancred. Naples and Sicily were subdued in 1194 by the emperor of Germany; in 1255 Manfred appears; in 1266 Charles of Provence; and others till Joan in 1414: after which follow the house of Arragon, and later kings.

Venice begins in the 10th century. The first coins are silver pennies marked VENECI. Then follow the coins of Henrico Dandulo in 1192, of Ziani in 1205, &c. Gold was first coined at Venice in 1280, and copper in 1471; but the silver groats are as old as 1192.

Florence. Silver was coined here in the 12th century, or before; but in 1252 the first gold coins struck in Europe after the 8th century made their appearance, and were named *florins* from the flower of the lily upon them. They were imitated by the popes, by France, and England. They have on one side St John the Baptist standing, on the other a large *fleur de lis*, and it is not doubted that the French *fleurs de lis* took their origin from these coins. They weigh a drachm, and are no less than 24 carats fine, according to Italian writers, and are worth about 12 shillings.

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Geneva first began to coin money in 1129, under the government of Conrad. Those of the dukes of Savoy began in the same century.

Aquileia. Coins were issued from this city by the patriarchs from 1204 to 1440.

Ferrara. Coins of the marquises from 1340.

11. French coins. During the race of Clovis, from 490 till 751, the coins are chiefly gold *trientes*, with some *solidi* and *semisses*. The former are of good workmanship, with the heads of kings. The reverse has a cross, with the name of the town where they were struck.

The coins of the second race begin with Pepin in 751, and continue till Hugh Capet in 987. The coins of the first race are elegant, but those of the second entirely the reverse, being almost all silver pennies, and seldom bearing the portrait of the king. Those of Charlemagne have only CAROLUS in the field; while the reverse bears R. F. or some such inscription; though one piece struck at Rome has a rude bust of him. The coins of Louis le Debonnaire are better done.

The third race begins with Hugh Capet in 987, and extends to this time. The coinage did not begin to improve till 1226 under St Louis, when the groat appears. Its name in Italian is *grosso*, in French *grosse*, in English *groat*, or great coin; so called from its size in comparison with the penny; and it passed from Italy to France, to Germany, and to England. After the conquest of France by the English, base coins of many kinds were introduced; and in the year 1574, in the time of Henry III. copper was first introduced into the French coinage. Besides these, the other remarkable coins of France are, the blancs or billon groats first issued in 1348; the *ecus a la couronne*, or crowns of gold, so called from the crown on one side, and begun by Charles VI. in 1384; those of Ann of Bretagne in 1498: the *teston*, or piece with the king's head, of Louis XII; the *Henri* of Henry II. with Gaul sitting in armour, and a Victory in her hand. There are many coins of Cardinal Bourbon, elected king in 1589; and in 1642, Louis XIV. takes the title of CATALONIÆ PRINCEPS. The first *louis d'or* made its appearance in 1640; but such was the poverty of France, if we believe certain authors, that in 1719 the duke of Orleans regent struck copper for silver.

12. Spanish coins. The most early series of these consists almost entirely of trientes, finely done. On one side they have the head of the king with his name, and on the other a cross, with the name of the town, commonly in Bætica, or the south part of Spain, where there were a great many Roman colonies, and which was fertile to a proverb. The Moresque coins of Spain, like those of the rest of the Mohammedan states, present us only with insipid inscriptions on both sides. Indeed the Mohammedan religion by its absolute refusal to allow the representation of any living creature, has prevented the progress of coinage in any degree throughout those regions which it has overspread.

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spread. The inscription on the ancient Spanish coins are in the Cufic or old Arabic characters.

13. Portugal. No description of the coins of this kingdom has yet appeared.

14. Germany. No account of the German coins has been published; though it is well known that not only the emperors, but many of the cities, particularly those called *Hanse-towns*, issued money; and many of the coins issued by the cities were superior in elegance even to those issued by the emperors.

15. Denmark. Here the coinage begins with Canute the Great in 1014. The pieces are at first extremely rude, ornamented only with rings and Runic characters. These are succeeded by copper pieces, some of which have a cross, others a pastoral staff, on one side, with the letter A on the other, Later coins have strokes IIII, &c. all round them; but those of Harold, Hardicanute, and Magnus Bonus, in 1041, are of neat workmanship, and have the portraits of the princes at half length. The coins of Nicolas, or Niel, as he is called by the Danes, are rude, as well as those of Waldemar I. and the celebrated Margaret. In 1376 Olaf caused money to be struck with a grinning full face, with a crowned O upon the other side. "The Swedes (says Mr Pinkerton) took these coins extremely ill, as they thought they grinned at them." Silver was first coined in Denmark by Philippa queen of Eric, and daughter to Henry IV. of England.

16. Sweden. The coinage of this kingdom began in 818 under Biorno, on the plan of Charlemagne. The coins are marked with a cross. Next follow those of Olaf in 1019: which Mr Pinkerton supposes to have been the first true Swedish coins; and that the art of coinage first passed from England into Denmark in the time of Canute the Great, and from Denmark into Sweden. These coins were struck on the English model. During the time that Sweden was subject to Denmark, or miserably harassed by the Danes, the coins of both kingdoms were the same; but after the time of Gustavus Vasa many elegant pieces appear. In 1634, dollars were coined with the portrait of Gustavus Adolphus, who was killed two years before: on the reverse they have the arms of Sweden, with the chemical marks of mercury and sulphur. In 1716, 1717, and 1718, Charles XII. being in extreme want of money, issued small copper coins with Saturn, Jupiter, Mars, &c. upon them, to go for dollars; and on account of this scheme, Baron Goertz, the suggestor of it, was brought to the block.

17. Norway. The coins of this country begin with Olaaf in 1006; after which time there are various coins of other princes; but copper was not coined till the year 1343.

Besides the coins already mentioned, there are ecclesiastic coins of France, Germany, Denmark, Sweden, Norway, &c. Those of Denmark and Sweden are numerous, but the Norwegian coins of this denomination are rare. Mr Pinkerton describes a silver one in his possession as having arms and a mitre, with the inscription on one side, SANCTUS OLAWS REX NORVEY; on the reverse, OLAWS DEI GRA. ARCEP. NID'SEN, meaning NIDROSIENSIS, or archbishop of *Nidros*, now Drontheim.

18. Bohemia. The coinage of this kingdom appears at a very early date, viz. in the year 909, under Duke Boleslaus I. These coins are followed by others of Boleslaus II. and Emma his wife in 970; of Boleslaus III. in 1002; Jaromir in 1020; Udalrich in 1030, and other princes. The *bracteate* money of Ottocar I. was coined in 1197.

19. Poland. The coinage of this country is nearly as ancient as that of Bohemia. The coins are on the German model, but no particular account of them has been published.

20. Russia. None of the Russian money appears to be more ancient than the 13th century. The first are the *kopecks* or silver pennies, which have upon them rude figures of animals on one side, and a man standing with a bow or spear on the other. There are likewise coins of Moscow struck by Aristoteles the architect in 1482. The *roubles* or dollars and their halfs. There are some of the impostor Demetrius in 1605, which are very scarce.

21. Prussia. The first Prussian coins were struck at Culm by the Teutonic knights in 1230. They were silver pennies, and upon the German plan. In the next century were struck shillings, groats, and *schots;* the last were the largest, and are extremely rare. They have the Prussian shield, an eagle surmounting a cross, with a rose-shaped border, MONETA DOMINORUM PRUSSIÆ: on the reverse is a cross fleurie, within a border of a similar kind, having the inscription HONOR MAGISTRI, JUSTITIAM DILIGET.—Gold coins were struck in the same century. In the time of Copernicus the money was so debased, that 12 or 13 marks were worth but one of pure silver.

22. England. The English coins are of various kinds.

1st. *Heptarchic.* These are only of two sorts, viz. the *skeatta* or penny of silver, and the *styca* of copper. Few of the pennies appear till after the year 700; though some are met with which bear the name of Ethelbert I. king of Kent, as old as 560. At first they had only rude figures of serpents, but in latter times legends were likewise added. Most of these pennies have pagan symbols upon them. The styca was only coined in Northumberland, and was a very small piece, about the value of half a farthing.

2d. Coins of the *chief monarchs* of England. Mr Pinkerton denies that an end was put to the heptarchy by Egbert in 832, as is commonly supposed; though he owns that he was *chief monarch* of the country, as several others had been before him. Edgar, who reigned in 959, according to him, was the first king of England; and the coins of the chief monarchs form almost a complete series from the time of Egbert to Edgar. The only chief monarch of whom there are no coins is Ethelbald, who reigned in 857. Most of these coins bear rude portraits; but the reverses are sometimes curious and interesting. Some have views of cathedrals and other buildings; particularly one of Edward the Elder in 900; which has the cathedral of York with three rows of windows, round arched as the other Saxon and Norman buildings: the Gothic arch being quite unknown till after the 12th century. Some coins of Anlaf king of Northumberland have the famous raven, the Danish ensign: and those

those of other princes have frequently very curious reverses.

3d. *Ecclesiastic* coins appear of the archbishops of Canterbury, Wulfred in 804, Ceolnoth, in 830, and Plegmund in 889.

4th. Coins of the *kings* of England. The silver penny, which had begun during the heptarchy, continued to be the general coin after the kingdom had been united under one head; and extends in a continued series from Egbert almost to the present reign. The only kings wanting are Edmund Ironside, Richard I. and John, At first the penny weighed $22\frac{1}{2}$ grains: but towards the close of the reign of Edward III. it fell to 18 grains; and in that of Edward IV. to 12. In the time of Edward VI. it was diminished to 8 grains; and in Queen Elizabeth's reign to $7\frac{1}{31}$; at which it still continues.

Halfpennies and farthings were first struck in silver by Edward I. in 1280; the former continued to the time of the commonwealth, but the latter ceased with Edward VI. The groat was introduced by Edward III. in 1354, and continues to this day, though not in common circulation. The half-groat or two-pence is of the same date, and also continues to the present time.

Shillings were first coined by Henry VII. in 1503. At first it was called *testoon*, from the *teste*, *tete*, or head of the king upon it; the name *shilling* being derived from the German *schelling;* under which appellation coins had been struck at Hamburgh in 1407. The crown was first coined in its present form by Henry VIII. Formerly it had appeared only in gold, whence the phrase of crowns of gold; though these indeed were the largest gold coins known for a long time in France and other countries on the continent, being worth about 10s. sterling. They had their name from the crown stamped on one side, and were first coined by Charles VI. in 1384, and continued till the time of Louis XIV. The half-crown, sixpence, and threepence, were coined by Edward VI. In 1558 Queen Elizabeth coined three halfpenny, and in 1561 three farthing pieces; but they were discontinued in 1582. From the year 1601 to the present time the coins of England remain the same.

Gold was coined in England by Henry III. in 1257; the piece was called a *gold penny*, and was larger than the silver one; and the execution is by no means bad for the time. The series of gold coinage, however, commences properly from Edward III. In 1344, this monarch first struck florins, in imitation of those in Italy; and it is remarkable, that though these coins at the time they were first issued bore only six shillings value, they are now intrinsically worth 19s.; so much has the value of gold increased since that time. The half and quarter florin were struck at the same time, but only the last has been found. The florin, however, being found inconvenient, gave place to the noble of 6s. 8d. value, and exactly half a mark. The latter had its name from being a limited sum in accounts: and was eight ounces in weight, two thirds of the money pound. It is sometimes also called *selibra*, as being one-half of the commercial pound of 16 ounces. The noble had its name from the nobility of the metal; the gold of which it was coined being of the finest sort. Sometimes it was called *rose noble*, from both sides being impaled in an undulating circle. It continued with the half and quarter noble to be the only gold coin till the angels of Edward IV. appeared in 1465. These had their name from being stamped with the image of Michael and the dragon. The angelets of 3s. 4d. value were substituted in their place. In 1527 Henry VIII. added to the gold coined the crown and half-crown at their present value; and the same year he gave *sovereigns* of 22s. 6d. and *ryals* of 11s. 3d. angels at 7s. 6d. and nobles at their old value of 6s. 8d. In 1546 he caused sovereigns to be coined of the value of 20s. and half-sovereigns in proportion. His gold crown is about the size of our shilling, and the half-crown of six-pence, but thin. All his coins, however, gold as well as silver, are much debased; and it was not without much labour and trouble that Edward VI. brought it back to its former standard. On the union of the two crowns, James gave the sovereign the name of *unite;* the value continuing of 20s. as before. He coined also rose-ryals of 30s. value, spur-ryals of 15s. angels of 10s. and angelets of 5s. Under the commonwealth, the sovereign got the name of the *twenty-shilling* piece, and continued current till the coinage of guineas. These were so called from their being coined of Guinea gold, and were at first only to go for 20s. though by an universal but tacit consent they always passed for 21s. Half-guineas, double guineas, and five guinea pieces, were also coined during the same reign; which still continue, though the two latter are not in common circulation. Quarter guineas were coined by George I. and likewise by his present majesty; but they were found so troublesome on account of their small size, that they were stopped within a year or two, when received at the bank of England, and thus are not to be met with at present. A few pieces of 7s. value have likewise been coined, and are known by the lion above the helmet; but none have been issued. In 1688 the guinea rose to 21s. 6d. and continued to increase in value till 1696, when it was as high as 30s.; but after the recoinage in 1697 and 1698 it fell by degrees, and in 1717 was at its old standard of 21s. and at that time silver was fixed at its present standard value, viz. as 1 to $15\frac{1}{2}$ in weight.

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Though the first money coined in Britain, as we have already observed, was copper, yet, excepting the Northumbrian stycas, no copper coin was found in England from the time of the Saxon conquest till the year 1672. An aversion to a copper coinage it seems was prevalent throughout the nation; and Queen Elizabeth, who without hesitation used base money for Ireland, yet scrupled at coining copper for England. This want of small coin occasioned such an increase of private tokens for halfpennies and farthings that it became a serious object to government; and in 1594 a copper coinage was seriously thought of. This year a small copper coin was struck about the size of a silver twopence, with the queen's monogram on one side, and a rose on the other; the running legend on both sides being, THE PLEDGE OF A HALFPENNY. Of this there are patterns both in copper and silver, but both of them soon fell into disuse. On the 19th of May 1613, King James by royal proclamation issued farthing tokens. They are generally of the same size with the two pence, with two sceptres in saltier surmounted with

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with a crown, and the harp upon the other; with an intention, as it would seem, that if they were refused in England, they might pass in Ireland. In 1635 Charles I. coined those with the rose instead of the harp; but the circulation of these was entirely stopped by the vast number of counterfeits which appeared, and by the king's death in 1648. After this the private tokens began again to be circulated, till put a stop to by the coinage of farthings in 1672. The workmanship of the tokens is quite contemptible. In 1672 the halfpence as well as the farthings which had been struck two years before began to circulate. They were of pure Swedish copper, the dies engraved by Roettier; and they continued till the year 1684, when some disputes arose about the copper lately obtained from the English mines. Tin farthings were coined with a stud of copper in the centre, and inscribed round the edge as the crown pieces, with NUMMORUM FAMULUS. 1685 or 1686. In 1686 halfpence of the same kind were coined; and the tin coinage continued till the year 1692, to the value of more than 65,000l.; but next year the tin was all called in by government, and the copper coinage recommenced. The farthings of Queen Anne are all trial pieces, excepting those of 1714, the last year of her reign. "They are (says Mr Pinkerton) of exquisite workmanship, exceeding most copper coins either ancient or modern, and will do honour to the engraver Mr Croker to the end of time." The one, whose reverse is Peace in a car, PAX MISSA PER ORBEM, is the most esteemed; and next to it the BRITANNIA under a portal. The other halfpence and farthings are less valuable.

23. Scotland. Silver pennies of Alexander I. who reigned in 1107, are believed to exist; and there certainly are some of Alexander II. in 1214. There are likewise coins of David in 1124; but perhaps none of Malcolm IV. his successor, whose reign was very short. There are many coins of William I. in 1165; and a large hoard of his pennies was found at Inverness in 1780.

The money of Scotland continued to be of the same value with that of England till the country was drained by the vast ransom of David II. after which it became necessary to reduce its size; and so much did this diminution affect England, that Edward III. found himself obliged to lessen the English coin also. The diminution of the Scottish coin, however, continued still to go on until it became impracticable to keep par with that of England. In the first year of Robert III. it passed only for one half of its nominal value in England: in 1393, Richard II. ordered it only to go for the weight of the genuine metal it contained. In 1600 it had sunk to such a degree as to pass only for a twelfth part of the English money, and continued at that low ebb till the coinage of Scotland was entirely cancelled by the union of the two kingdoms.

Of silver coins we have only pennies till the year 1293, when Edward I. having coined halfpence and farthings, Alexander III. of Scotland coined also halfpence, of which we have a few, but no farthings are to be met with; but there are silver farthings of Robert I. and David II. The latter introduced the groat and half-groat, which completed the set of Scottish silver. It continued unaltered till the time of Queen Mary, when they all ceased to be coined in silver, on account of the high price of that metal. In 1553 shillings were first coined, with the bust of the queen on one side and the arms of France and Scotland on the other. The silver crown was first coined in 1565, which went for 30s. Scots; lesser pieces of 20s. and 10s. having likewise been struck, and marks of silver, worth 3s. 4d. English, were also coined about the same time. These coins have upon them the marks XXX. XX. X. to denote their value. They are commonly called Cruickstone dollars, from the palm-tree upon them, mistaken for a remarkable yew at Cruickstone near Glasgow, where Henry Darnley resided. It is described, however, in the act as a palm, with a "shell-padoc" (a tortoise) crawling up. This alludes to Darnley's marriage with the queen, as the motto from Propertius DAT GLORIA VIRES also implies. The motto NEMO ME IMPUNE LACESSET first appears on the Scottish coins in 1578, and the invention is given to the celebrated Buchanan. In 1582, the crown of an ounce weight went for 40s. Scots, and was accordingly marked XL.; in 1597 the mark was L. the Scottish money being then only one-tenth of the English: the mark was LX. in 1601, the value being then reduced to one-twelfth, at which it has ever since continued. In the time of Charles I. half marks, 40 and 20 penny pieces, were coined. In 1675 the Scottish dollars first appeared, in value 56s. Scots, with halves and quarters of proportional value. In 1686, James VII. coined 60s. 40s. 20s. 10s. and 5s. pieces; but only those of 40s. and 10s. are known, with these numbers under the bust. At the union of the kingdoms all the Scottish coins were called in, and recoined at Edinburgh, with the mark E under the bust to distinguish it: since which there has been no coinage in Scotland. The Scottish silver coins are in general equal, if not superior, in the workmanship to the English.

Gold was first issued by Robert II. about 30 years after Edward III. of England had coined the same metal in that country. The pieces were at first called St. Andrews, from the figure of that tutelar saint upon the cross, and who appears on the obverse with the arms of Scotland, and on the reverse a lion in a shield. The lion was another name for the largest gold coin in Scotland, from the arms of the kingdom upon it. The next was the unicorn, under James III.; which were followed by the bonnet-pieces of James V. These last are of admirable workmanship, being almost equal to the ancient coins in this respect. In imitation of the French, the monarch we speak of diminished the size of the coin without lessening its weight; an improvement not adopted by the English for a whole century. The last gold coined in Scotland was the pistole and half pistole, of twelve and six pounds Scots. These coins have the sun under the head. The gold coins of Scotland fell in the same proportion with the silver.

The copper coinage of Scotland is of more early date than that of England. It was preceded by money of *billon*, or copper washed with silver, called black money. James III. first coined black farthings in 1466; and this is recorded by historians as one of his greatest faults. This kind of coinage, however, continued as late as the reign of James VI. In his time the

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the true copper coinage began; but as the value of Scottish money had now declined almost to the utmost, the pieces suddenly assumed a form almost resembling that of the French coins. The *bodle*, so called from Bothwell the mintmaster, being equal in size to the *liard*, and worth two pennies Scottish, was struck. The billon coin, formerly called *bas piece*, and worth six pennies Scots, was now coined in copper, and termed the *baw-bee*. Thus it corresponded with the French half sol and English halfpenny, the Scots penny being now equivalent to the French *denier*. Some pieces named *Atkinsons* were coined by James VI. in 1582, when the Scottish money was to the English as 1 to 8; but on its being still farther reduced, they went for 8 pennies, a third more than the value of the baw-bee. Besides these there were the hardie and plack, the former being worth three and the latter four pennies Scots. This coinage continued through the reigns of Charles I. and II. but Scottish coins of the former are, perhaps, the scarcest of any.

24. Ireland. The first coins introduced into this kingdom seem to have been those of the Danes, and which have only a number of strokes around them instead of letters. In the tenth century, however, this coinage had been considerably improved; and in 930 and 994 there are pennies struck in Dublin, with the inscription ON DVFLI or DYFLI, *Duflin* or *Dyflin* being the Danish name of that city. There are likewise coins of the Irish princes themselves, and of the English monarchs, struck in Ireland as early as the ninth century; and it is asserted by some, that Ireland even in these days had been conquered by England; of which, indeed, these coins seem to be a proof. None of the Irish coins of Henry II. are to be met with, but we have some of the coins of John; and from his time to that of Henry V. the Irish coins are known by a triangle enclosing the king's head, which appears also upon the coins of other nations at this period. The harp does not appear upon the Irish coins till the time of Henry VIII. Till the time of this monarch, the English and Irish coins are the same; but the same debasement of the coin which at that time took place in England extended also to Ireland; but in 1601 copper halfpence and farthings were coined also for this kingdom. These circulated in Ireland when James VI. issued his farthing-tokens of copper, the latter being of two sizes, that if they failed in England they might be sent to Ireland as pennies and halfpence. In 1635 a mint was established in Dublin by Charles I. but it was stopped by the Irish massacre, and the many disturbances which followed; since which time the scheme has not been resumed. After the massacre, St Patrick's halfpence and farthings were coined by the Papists, bearing the legends FLOREAT REX, and on the reverse ECCE GREX; on the farthing QUIESCAT PLEBS. Copper tokens were struck by towns and tradesmen, as in England and Scotland. In 1680, halfpence and farthings were issued by authority, with the harp and date. In 1689, James II. having invaded Ireland, instituted a mint, and coined shillings and half crowns of all the refuse metal he could find, particularly some brass guns were employed, whence the coinage is commonly called *gun-money*. Even this metal, however, soon became so scarce, that a diminution in its size is quite apparent from June 1689 to July 1690; and as the month of their mintage is marked upon them, this decrease is easily perceived. In March 1690, pennies of lead mixed with tin were issued; and on the 15th of June the same year, crowns of white metal were coined; but these are now very scarce. In 1722, the patent for coining halfpence and farthings was given to William Wood, which excited such discontent in Ireland. From the small size allowed by the patent to these pieces, it was supposed that the patentee would have gained 60,000l. but as he caused them to be struck of a size still smaller, his gains were estimated at 100,000l. The coins, however, are of admirable workmanship, and very fine copper, bearing the best portrait of King George I. to be found any where. Sir Isaac Newton, at that time at the head of the mint, declared that they were superior to the English coins in every thing except the size. In 1737 the Irish halfpence and farthings, with the harp on the reverse, were coined, and continue to the present time. In 1760, there was such a scarcity of copper coin, that some private persons applied for leave to coin halfpence, which appeared with a very bad portrait of George II. and the words VOCE POPULI around it. No gold or silver has been coined in Ireland since the massacre of 1641.

TABLE V. *Modern Medals, properly so called.*

1. Scottish medals. These take the lead in the present article, the first modern medals of gold being those of David II. struck between the years 1330 and 1370. Only two of them are known to exist; one in the collection of Mr Barker of Birmingham, and the other in that of Dr Hunter. In 1487, there is a medal of James III. sent to the shrine of St Amboise in France. It is described as of two inches and a third in diameter; the weight near two ounces; having on the obverse a beardless king, with long hair, sitting on a throne, holding in one hand a naked sword; in the other a shield, with the Scottish arms. On the borders of the canopy above the throne is an inscription in Gothic letters, IN MI DEFFEN, being corrupt French for *In my defence*; a common motto in the Scottish arms. Above the canopy is VILLA BERWICHI: the reverse bears St Andrew and his cross, SALVUM FAC POPULUM TUUM DOMINE. There is also a medal of James IV. in the collar of St Michael, having on the reverse a Doric pillar surmounted by a young Janus, standing on a hill, beyond which is the sea, and land on either side. This, however, is by some suspected to be a forgery.

The most remarkable Scottish medals are those of the unfortunate Mary. The first is properly French, having been issued at her coronation as queen of France, along with her husband King Francis II. On the obverse of this piece there are portraits of Francis and Mary, face to face, with three legends around them, the outermost containing their titles; the middle one the following sentence: HORA NONA DOMINUS J. H. S. EXPIRAVIT HELLI CLAMANS; the innermost the name of the city (Paris). On the reverse are the arms of France and Scotland. Fine testoons were also coined upon the same plan, and are now so rare that Dr Hunter gave ten guineas for one which

Modern Medals.

which is in his collection. The same portraits appear on the fine crown of Mary and Henry, in 1565, which is so rare as to be esteemed a medal of the highest value; and Mr Pinkerton imagines, that if offered to sale it would bring 40 or 50 guineas.

Another remarkable medal of Mary represents her full-faced and weeping, with the inscription, O GOD GRANT PATIENCE IN THAT I SVFFER VRANG. The reverse has in the centre, QUHO CAN COMPARE WITH ME IN GRIEF, I DIE AND DAR NOCHT SEEK RELIEF; with this legend around, HOURT NOT THE (figure of a heart) QUHAIS JOY THOU ART. There are also many counters of this unfortunate princess, being thin silver pieces of the size of a shilling. "They all appear (says Mr Pinkerton) to have been done in France, by the direction of Mary, who was fond of devices. Her cruel captivity could not debar her from intercourse with her friends in France, who must with pleasure have executed her orders, as affording her a little consolation."

The coronation medal of Charles II. struck at Edinburgh for his inauguration, June 18. 1663, is remarkable as being the only one ever coined of Scottish gold, and the first in Britain struck with a legend on the edge. With respect to the workmanship, it is inferior to Simon's. Of these medals only three are known to exist, of which one is in the Museum. It is not uncommon in silver; in which case it sometimes wants the legend on the edge.

2. Italian medals. These appear in the 15th century, and from that time successively in most European countries. Vittore Pisano, a painter of Verona, is celebrated as the restorer of the art, but it remains to be accounted for how the medals of King David, already mentioned, came to exist so long before. Mr Pinkerton considers this artist rather as an inventor than a restorer, his medals having no resemblance to the ancient coins, as being large, and all cast. They were first modelled in wax, then a mould taken from the model in fine sand and other ingredients. After a good cast was procured, it was touched up, and made a model for the rest. These medals of Pisano, are almost always inscribed *Opus Pisani Pictoris*. The portraits of a great number of illustrious men were done by him in this manner; and in the British Museum is a large brass medal of Pisano by himself.—Other artists were Boldu, Marescotto, Matthæus de Pastus, Sperandes, Misaldone, &c. Towards the end of the century, however, the medals began to assume a more elegant appearance; and the papal ones are not only the most elegant but the most ancient series of all the modern medals. The improvement began in the reign of Alexander VI. so famous for his own crimes, and those of his nephew Cæsar Borgia. His successors, Julius II. Leo X. Hadrian VI. and Clement VII. had many of their medals designed by Raphael, Julio Romano, and other eminent painters, and the engraving executed by artists of equal merit. Among these were the celebrated Cellini, and the noted Paduan forgers of Roman coins, Cavino and Bassiano. In 1644, Cormanni, a medallic artist, was imprisoned on account of a piece which represented the Pope upon one side, and Olympia Maidalchina, the *relation* of his holiness, on the other. The unfortunate Cormanni poisoned himself. About this time the family of the Hamerani, originally from Germany, began to engrave the papal medals; which they did with surprising merit for several generations. Each of the daughters did a fine medal, as we are informed by Venuti.

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Besides the papal medals, many have been issued by the various states of Italy. There are medals of Frederic II. of Sicily in 1501, of several Venetian generals in 1509, of Alfonso duke of Ferrara in 1511, and of the celebrated Andrew Doria in 1528.

3. French medals. Till the reign of Louis XIV. the medals of this country are neither fine nor numerous; but this monarch exceeds all modern princes in this way. Many of his pieces are well designed and executed, though objectionable on account of their falsehood.

4. Danish medals. These appear of Christian II. in 1516, of Frederic and Sophia in 1532, of Frederic I. and Christian III. in bonnets worn in the 16th century. The elephant of the house of Oldenburg is frequent upon Danish medals.

5. Swedish medals. These begin with Gustavus Vasa; and several of Christina are likewise to be met with. There are also some curious ones of Charles XII.

6. Dutch medals. These begin in 1566; and many of them are remarkable for maps and plans, which must be very interesting to posterity. "Had the Greeks and Romans (says Mr Pinkerton) given us maps and plans, what a fine system of ancient geography and topography a cabinet of medals must have been!"

7. Medals of Spain, Portugal, and Germany. The Spanish medals began with Gonsalo in 1503, many of which are curious and interesting. Under Charles V. there are many curious Spanish medals; but those of Germany begin with Frederic in 1453. They are extremely numerous; as we may easily suppose from the greatness of the empire, and various states which compose it. There is a famous medal of Sebastian king of Portugal, famous for his unfortunate expedition into Africa in 1578; with his bust, full face, and three quarters in length. On the reverse is a shell-fish in the sea, with the moon and seven stars, bearing the inscription SERENA CALSA FAVENT. There is also a curious lozenge-shaped coin of the same, with the arms of Portugal, and the king's name and title: On the reverse is a cross with the inscription IN HOC SIGNO VINCES, 1578.

8. Satiric medals. These began almost as soon as the knowledge of the art of coining medals was revived. They seem to have been almost unknown to the ancients. One indeed of the emperor Gallienus is supposed to have been satiric. It has on the front the emperor's bust, with the inscription GALLIENÆ AUG. the reverse is Peace in a car, PAX UBIQUE; but this has been proved to be only a blundered coin. Some other ancient medals, however, are not liable to this objection. The first modern satiric medal published was that of Frederic king of Sicily in 1501, against his antagonist Ferdinand king of Spain. It has on one side the head of Ferdinand, with the inscription FERDINANDUS R AR. VETUS VULPES ORBIS; on the reverse a wolf carrying off a sheep, JVGVM MEVM SVAVE EST ET ONVS MEVM LEVE. Many others have been struck, of which the wit would now perhaps be difficult

Abbreviations.

difficult to be found out: but of all nations the Dutch have most distinguished themselves in this way; and paid very dear for their conduct, as they brought upon themselves by one or two satiric medals the whole power of France under Louis XIV.

9. English medals. The first of these is in the duke of Devonshire's collection. It is of a large size, and done on the plan of the early Italian medals. It has on the reverse the arms of Kendal, with the inscription TEMPORE OBSIDIONIS TURCORUM, MCCCCLXXX. On the other side is a portrait with IO KENDAL RHODI TVRCVPELLERIVS. It was found last century in Knaresborough forest; but Mr Pinkerton has no doubt of its having been done in Italy. The next is that of Henry VIII. in 1545, and is of gold, larger than the crown-piece, with the king's head upon the obverse, and three legends within each other, including his titles, &c. The reverse contains two inscriptions, declaring him to be the head of the church; the one in Hebrew, the other in Greek. It was imitated exactly by Edward VI. whose coronation medal is the first we have. There are two medals of Philip and Mary, whose execution is tolerably good; but those of Elizabeth are very poor. There are good medals of James I. and his queen; with a fine one of Charles I. and Henrietta, though the workmanship is much inferior to the antique. There are many good medals of Charles, with various devices upon their reverses. Under the commonwealth the celebrated Simon produced medals which are deservedly reckoned the most admirable pieces of modern workmanship. There are many good medals of Charles II. James II. and William III. Some are also found of James after his abdication. Some fine gold, silver, and copper medals, were issued in the time of Queen Anne; the two last affording a series of all the great actions of the duke of Marlborough. About the year 1740, a series of medals was engraved in London by Dassier, a native of Geneva, containing all the kings of England; being 36 in number. They are done upon fine copper, and executed with great taste. There are besides many medals of private persons in England; so that it may justly be said, that this country for medals exceeds almost every other in Europe.

To this account of modern coins and medals we shall add that of another set called *siege-pieces*, and which were issued during the time of a siege in cases of urgent necessity. These were formed of any kind of metal; sometimes of no metal; and Patin mentions a remarkable one struck at Leyden in 1574, when the place was besieged by the Spaniards. It was of thick paper or pasteboard, having a lion rampant, with this inscription, PVGNO PRO PATRIA, 1574; and on the reverse, LVGDVNVM BATAVORVM. There are various siege-pieces of Charles I. both in gold and silver, some of the latter being of the value of 20 shillings.

The *nummi bracteati* are a species of modern coins somewhat between counters and money; and have their name from the word BRACTEA, a spangle or thin bit of metal. They are commonly little thin plates of silver, stamped as would seem with wooden dies upon one side only, with the rude impression of various figures and inscriptions. Most of them are ecclesiastic, and were struck in Germany, Switzerland, Denmark, Sweden, Norway, and a few in Poland. They continued to be in use in Germany till the end of the 15th century; and some are still used in Switzerland at this day.

TABLE of ABBREVIATIONS used in the Legends of Medals; from Mr Pinkerton.

GREEK COINS.

A.

A. Athens, Argos, Aulus, Asylum; primi or first; as Εφεσιων A. Ασιας, Ephesians, first people of Asia.
A. Abassus, Abdera, Abydus on Hellespont
AB. Abydus in Egypt
ABY. Abydus on Hellespont
AΘ. AΘP. Athens
AIΓ. Ægina
AIΓOΣΠO. Aigospotamos
AIA. Ælius, Ælia Capitolina
AIN. Ænos
AK.—AKPATAN. Agrigentum
AKI. Acilium
AKT. Actium
AΛE. Alexandria
AM. Amyntas
AMBP. Ambracia
AMΦI. Amphilochia
ANΘ. Ανθυπατον, Proconsul
ANTIΣ. Antissa
ANA. Anactoria
ANTI. Antium
AN. Ancyra
ANT. Antoninus, Antioch
AΞ. Axus in Crete
AON. Aonitæ
AOYE. Avenio, *Pell.*
AΠ. Appius
AΠA. Apamea
AΠO. Apollonia
AΠTA. Aptara
AP. Aradus, Harma
APΓE. Argennos
APΓ. Argos
API. Aricanda
APIM. Ariminum
APΣI. Arsinoë
APY. Aryca
APX. Αρχιερευς or Αρχον, high priest or magistrate
AΣIAPX. Asiarchæ, presidents of the games of Asia (B)
AΣ. Asylum
A. Σ. Πρωτοι Συριας, First of Syria
AΣK. Ascalon
AT. Atabyrium
ATAP. Atarnæ
AYΓ. Augustus
AYPHΛ. Aurelius
AY. AYT. Αυτοκρατορ, Emperor
AYTON. Αυτονομοι, enjoying their own laws
AΦI. Aphyta
AΦP. Africanus
AX. Achaii

B

B. Βουλης, Council: Berytus: Bithynia
BAΓHΔAO. Bagadaonia
BAΛ. Valerius
BH. Berytus
BITON. Bitontum
BOI. Bœotia
BPYN. Brundusium
BY. Byzantium

Γ.

Γ. ΓP. ΓPAM. Grammaticus, or keeper of the records
Γ. Gaius, or Caius
ΓA. Gallus, Gallerius, Gallienus
Γ. Γνωριμου, Illustrious
ΓEΛ. Gelas
ΓEP. Germanicus
ΓN. Gneius
ΓOPTY. Gortyna
ΓPA. Gravisca

Δ.

Δ. Decimus, Dymæ
ΔAK. Dacicus
ΔAM. Damascus
ΔAP. Dardanum
ΔH. Δημος, the people
ΔHMAPX. EΞOYΣ. with Tribunitian power
ΔE. Decelia
ΔEK. Decius

ΔEP.

(B) There were also Syriarchæ, Lyciarchæ, Galatarchæ, Bithyniarchæ, Cappadociarchæ, &c. *Morel. Spec.*

Abbreviations.

ΔΕΡ. Derbe in Lycaonia
ΔΗ. Delos
ΔΙ. Diospolis
ΔΡΕ. Drepanum
ΔΥΡ. Dyrrhachium

Ε.

Ε. Eryce
Ε. ΕΡΕΣ. Eresus
ΕΛΕΥ. Eleusis
ΕΛΕΥΘ. Ελευθεροι, Free
ΕΠΙ. Epidaurus
ΕΡΙ. Eriza in Caria
ΕΡΧ. Erchia
ΕΡΥ. Erythræ
ΕΤ. ΕΤΟ. Ετους, Year
ΕΤ. Etenna in Pamphylia
ΕΧ. Εχουσια, Power
ΕΥ. ΕΥΒΟ. Eubœa
ΕΥΣ. Ευσεϐης, Pious
ΕΥΤ. Ευτυχης, Happy
ΕΦ. ΕΦΕ. Ephesus

Ζ.

ΖΑ. Zacynthus
ΖΑΝΚΛ. Zancle, Messana anciently so called

Η.

Η. Elium
ΗΓ. Ηγεμονος, President
ΗΡΑΚ. Heraclea

Θ.

ΘΑ. Thasus
ΘΕ. Thespiæ
ΘΕΣ. Thessalonica
ΘΕ. ΘΗΒ. Thebæ

Ι.

Ι. ΙΕΡ. Ιερος, Sacred
ΙΕΡΑΠΥ. Hyerapytha
ΙΚΑΡ. Hiccara
ΙΛΙ. Ilium
ΙΟΥ. Julis, a city, or Julius
ΙΟΥΛ. Julia
ΙΠΑ. Hippana
ΙΡ. Irene Ins. *Pellerin.*
ΙΣ. Isus, Istiæa

Κ.

Κ. Caius; Κουιντος, Quintus
Κ. ΚΑΙΣ. Cæsar
Κ. Κ. Κοινον Κιλικιας, Community of Cilicia
ΚΑΙΛ. Cælius
ΚΑΛ. Chalcedon
ΚΑΛΛΙ. Callipolis
ΚΑΜΑ. Camara
ΚΑΝ. Canata
ΚΑΠ Capua
ΚΑΠΠ. Cappadocia
ΚΑΡ. Carrhæ
ΚΑΡΤ. Carthago
ΚΑΥ. Caulonia
ΚΕ. Ceos
ΚΕΦ. Cephalædis
ΚΙ. Cianus, Cibæum
ΚΙΛ. Cilbiani
ΚΛ. Clæonæ, Claudius
ΚΛΑ. Clazomene
ΚΝΙ. Cnidus
ΚΟ. Corinth
ΚΟΙΝ. Κοινον, Community
ΚΟΛ. Κολωνιας, Colony, Colophon
ΚΟΜ. Commodus
ΚΟΡ. Corcyra
ΚΡ. Cragus in Lycia
ΚΡΑ. Cranos
ΚΡΗ. Crete
ΚΤΗ. Ctemenæ, *Pell.*
ΚΥ. Cuma, Cydonium, Cyon
ΚΥΘ. Cythnus
ΚΥΠ. Cyprus
ΚΥΡ. Cyrene

Λ.

Λ. or L. Λυκαϐαντος, Year
Λ. Lucius
ΛΑ. Lacedæmon
ΛΑΜ. Lamea; Lampsacus
ΛΑΡ. Larissa
ΛΑΡΙ. Larinum
ΛΕ. ΛΕΥ. Leucas
ΛΕΟΝ. Leontium
ΛΗΜ. Lemnos
ΛΙΠ. Lipara
ΛΙΥΙ. Liviopolis
ΛΟ. ΛΩΚ. Locri
ΛΟΓ. Longone
ΛΥΓ. ΛΥΚ. Lyctus

Μ.

Μ. Marcus, Malea, Megalopolis, Mazaka
ΜΑ. Maronea, Massilia, Macedonia
ΜΑΓ. Magnesia
ΜΑΚΡΟ. Macrocephali
ΜΑΜ. Mamertini
ΜΑΣΣ. Massilia
ΜΑΖ. Mazara
ΜΕ. Menelais, on Syrian regal coins
ΜΕΝΕΚ. Menecrates
ΜΕ. ΜΕΓ. Megara, Megalopolis, Melite
ΜΕΓ. Μεγαλος, Great
ΜΕΣ. Messana
ΜΕΤΑ. Metapontum
Μ. ΜΗΤΡΟ. Metropolis
ΜΙ. Miletus
ΜΚ. Massaka of Cappadocia, on coins of Mithridates VI.
ΜΟΡ. Morgantia
ΜΥ. Mycenæ
ΜΥΡ. Myrlea
ΜΥΤΙ. Mytilene

Ν.

Ν. Naupactos
ΝΑΞ. Naxos
ΝΑΥΑΡΧ. Ναυαρχιδοι, enjoying a sea-port
ΝΕ. Nemea
Ν. ΝΕΩΚ. Neocori
ΝΕΟΠ. Neopolis
ΝΕΡ. Nerva
ΝΙΚ. Nicæum, Nicomedia
ΝΥΣ. Nysæi, on coins of Scythopolis, *Pell.*

Ο.

ΟΙ. Oethæi
ΟΝ. Οντος, Being
ΟΠΕΛ. Opelius
ΟΠ. Opus
ΟΡΥ. Orycus
ΟΡΧ. Orchomenus
ΟΥΠ. or ΥΠ Ουπατος or Υπατος, Consul
ΟΥΕΡ. Verus
ΟΥΗ. Verus
ΟΥΕΣΠ. Vespasianus
ΟΥΙΤΕΛ. Vitellius
ΟΦΡΥ. Ophrynium.

Π.

Π. Παρα, Προς, upon
Π. ΠΟΠΛ. Publius
Π. ΠΑ. Paphos or Paros
ΠΑΙΣ. Pæstum
ΠΑΝ. Panormus
ΠΑΡ. Paropinum
ΠΑΡΙ. Paros
ΠΑΡΘ. Parthicus
ΠΕ. Perinthus.
ΠΕΛ. Pella
ΠΕΡ. Pergus
ΠΕΡΤ. Pertinax
ΠΕΣΚ. Pescennius
Π. ΠΗ. Pelusium
ΠΙΝ. Pinamytæ
ΠΛΑ. Plateæ
ΠΟ. Pontus
ΠΟΛΥ. Polyrrhenum
ΠΟΣ. Posidonia
ΠΡΑΣ. Prassus
Π. ΠΡΥ. Πρυτανος, Præfect
ΠΡ. ΠΡΕΣ. Πρεσϐεος, Legate
ΠΡΟ. Proconnesus
ΠΡΟΔΙ. Προδικος, Curator
Π. ΠΡΩΤ. Πρωτος, First
ΠΤ. Ptolemais
ΠΥ. Pylos

Ρ.

ΡΟ. Rhodes

Σ.

Σ. ΣΑ. Salamis, Samos, Syria.
ΣΑ. Samosate
ΣΑΛΑΠ. Salapia
ΣΑΡ. Sardis
ΣΕ. Seriphus, Segeste
ΣΕΒ. Σεϐαστος, Augustus
ΣΕΛ. Selinus, Seleucia
ΣΕΠΤ. Septimius
ΣΙ. Siphnos
ΣΙΔ. Side
ΣΙΝΩ. Sinope
ΣΜΥ. Smyrna
ΣΤΡ. ΣΤΡΑ. Στρατηγος, Prætor
ΣΥΒ. Sybaris
ΣΥ. ΣΥΡΑ. Syracuse
ΣΥΡ. Syria
ΣΩ. Solæ

Τ.

Τ. Titus
ΤΑΒΑΛ. Tabala
ΤΑ. ΤΑΝΑ. Tanagra
ΤΑΡ. Tarentum, Tarsus
ΤΑΥΡ. Tauromenum
ΤΕ. Tementis
ΤΕΡ. Terina
ΤΗ. Tenus
ΤΙ. ΤΙΒ. Tiberius
ΤΡΑ. Trallis
ΤΡΙ. Tripolis
ΤΡΟ. Troizene
ΤΥΑΝ. Tyana
ΤΥ. Tyndarus
ΤΥΡ. Tyre (monogram)

Υ.

ΥΕ. ΥΕΛ. Velia
ΥΠ. ΥΠΑΤ. Υπατος, Consul

Φ.

Φ. Philip, Phœstus, Philuntium
ΦΑ. Phaselis
ΦΑΡ. Pharsalus
ΦΙ. Vibius, Philippopolis
ΦΙΝΕ. Phineium
ΦΛ. Flavius
ΦΟΚ. Phocæum
ΦΟΥΛ. Fulvia
ΦΥ. Phycus in Cyrene

Χ.

Χ. Chios
ΧΑΛ. Chalcis
ΧΕΡ. Chersonesus
ΧΙ. Chytri in Crete

Greek Numerals.

Α.	1.	Ι.	10.	Ρ.	100.
Β.	2.	Κ.	20.	Σ. or C	200.
Γ.	3.	Λ.	30.	Τ.	300.
Δ.	4.	Μ.	40.	Υ.	400.
Ε.	5.	Ν.	50.	Φ.	500.
ς. or ϛ	6.	Ξ.	60.	Χ.	600.
Ζ.	7.	Ο.	70.	Ψ.	700.
Η.	8.	Π.	80.	Ω.	800.
Θ.	9.	ϙ. or ϟ	90.	ϡ.	900.

Example.

Abbreviations.

Examples. I is 10: add A to I, and IA makes 11: so IB, 12; IΓ, 13, &c. K is 20, KA, 21, &c. PIA makes 111. The English word AIR marks the grand initial numerals. On coins the numerals are often placed in retrograde order; which makes no difference in the value, as every letter is appropriated to its number. Thus TAΓ or ΓAT imply the same, 333. But this advantage being unknown to the Roman numerals and Arabic cyphers, is apt to puzzle the beginner.

ROMAN COINS.

A

A. AULUS: in the exergue it implies the first mint, as ANT. A. coined at Antioch in the first mint
A. A. A. F. F. Auro, Argento, Ære, Flando, Feriundo
A. or AN. Annus
A. A. Apollo Augusti
A. F. A. N. Auli filius, Auli nepos
ABN. Abnepos
ACT. Actiacus, or Actium
AD. FRV. EMV. Ad fruges emundas
ADIAB. Adiabenicus
ADOP. Adoptatus
ADQ. Adquisita
ADV. Adventus
AED. Ædes
AED. P. Ædilitia potestate
AED. S. Ædes sacræ
AED. CVR. Ædilis Curulis
AED. PL. Ædilis Plebis
AEL. Ælius
AEM. or AIMIL. Æmilius
AET. Æternitas
AFR. Africa, or Africanus
ALBIN. Albinus
ALIM. ITAL. Alimenta Italiæ
ANN. AVG. Annona Augusti
A. N. F. F. Annum Novum Faustum Felicem
ANIC. Anicius
ANN. DCCCLXIIII. NAT. VRB. P. CIR. CON. Anno 864, Natali Urbis Populo Circenses constituti
ANT. AVG. Antonius Augur
ANT. Antonius, or Antoninus
AP. Appius
A. P. F. Argento Publico Feriundo
A. POP. FRVG. AC. A Populo Fruges Acceptæ
AQ. or AQL. Aquilius
AQVA MAR. Aqua Martia
ARAB. ADQ. Arabia Adquisita
ARR. Arrius
AVG. Augur, Augustus, Augusta
AVG. D. F. Augustus Divi Filius
AVGG. Two Augusti
AVGGG. Three Augusti
AVR. or AVREL. Aurelius

B.

B. The mark of the second mint in any city
BON. EVENT. Bonus Eventus
B. R. P. NAT. Bono Reipublicæ Nato
BRIT. Britannicus
BRVT. Brutus

C.

C. Caius, Colonia
C. A. Cæsarea Augusta
C. CAE. or CAES. Cæsar
CAESS. Cæsares
CARTH. Carthage
CEN. Censor
CENS. P. Censor Perpetuus
CEST. Cestius, or Cestianus
CIR. CON. Circum Condidit, or Circenses Concessit
CIVIB. ET SIGN. MILIT. A. PARTH. RECVP. Civibus et Signis Militaribus a Parthis Recuperatis
CN. Cneius
COEL. Cœlius
CON. OB. Constantinopoli Obsignata, or Constantinopoli Officina secunda, or Conflata Obryzo
COL. Colonia
CON. SVO. Conservatori suo
CONCORD. Concordia
CL. V. Clypeus Votivus
COMM. Commodus
CLOD. Clodius
CL. or CLAVD. Claudius
COS. Consul
COSS. Consules
CORN. Cornelius
CVR. X. F. Curavit Denarium Faciendum

D.

D. Decimus, Divus, Designatus
DAC. Dacicus
D. F. Dacia felix
D. M. Diis Manibus
DES. or DESIG. Designatus
DICT. Dictator.
DOMIT. Domitianus
D. N. Dominus noster
DID. Didius
D. P. Dii Penates
DV. Divus

E.

EID. MAR. Idus Martiæ
EX. CONS. D. Ex Consensu Decurionum
EX. S. C. Ex Senatus Consulto
EQ. ORDIN. Equestris Ordinis
EX. A. PV. Ex Argento or Auctoritate Publica
EXER. Exercitus
ETR. Etruscus

F.

F. Filius, or Filia, or Felix, or Faciendum, or Fecit
FEL. Felix
FELIC. Felicitas
FL. Flavius
FLAM. Flamen
FORT. RED. Fortunæ Reduci
FOVRI. Fourius for Furius
FONT. Fonteius
FRVGIF. Frugiferæ (Cereri)
FVL. Fulvius
FVLG. Fulgerator

G.

G. Gneius, Genius, Gaudium
GA. Gaditanus
G. D. Germanicus Dacicus
GEN. Genius
GERM. Germanicus
GL. E. R. Gloria Exercitus Romani
GL. P. R. Gloria Populi Romani
GOTH. Gothicus
G. P. R. Genio Populi Romani
G. T. A. Genius Tutelaris Ægypti, or Africæ

H.

HEL. Helvius
HEL. Heliopolis
HER. Herennius, or Herennia
HO. Honos
HS. Sestertius

I.

I. Imperator, Jovi, Julius
IAN. CLV. Janum clusit for clausit
IMP. Imperator
IMPP. Imperatores
I. S. M. R. Juno Sospita, Mater or Magna Regina
IT. Italia, Iterum
ITE. Iterum
IVL. Julius or Julia
IVST. Justus
I-I. S. Sestertius
I. O. M. SACR. Jovi Optimo, Maximo, Sacrum
II. VIR. Duumvir
III. VIR. R. P. C. Triumvir Reipublicæ Constituendæ
IIII. VIR. A. P. F. Quatuorvir, or Quatuorviri, Auro, or Argento, or Ære, Publico Feriundo
IVN. Junior

L.

L. Lucius
LAT. Latinus
LEG. PROPR. Legatus Proprætoris
LEG. I. &c. Legio Prima, &c.
LEP. Lepidus
LENT. CVR. X. F. Lentulus Curavit Denarium Faciundum
LIBERO P. Libero Patri
LIB. PVB. Libertas Publica
LIC. Licinius
L. S. DEN. Lucius Sicinius Dentatus
LVC. Lucifera
LVD. CIR. Ludi Circenses
LVD. EQ. Ludi Equestres
LVD. SAEC. F. Ludos Sæculares Fecit

M.

M. Marcus, or Marius
MAR. CL. Marcellus Clodius
M. F. Marci Filius
M. OTACIL. Marcia Otacilia
MAG. or MAGN. Magnus
MAC. Macellum
MAR. Martia (aqua)
MAR. VLT. Marti Ultori
MAX. Maximus
MES. Messius
METAL. Metallum
MINAT. Minatius
MINER. Minerva

M. M. I. V.

Abbreviations.

M. M. L. V. Municipes Municipii Julii Uticensis
MON. or MONET. Moneta

N.

N. Nepos or Noster
N. C. Nobilissimus Cæsar
NAT. VRB. Natalis Urbis
NEP. Nepos
NEP. RED. Neptuna Reduci

O.

O. Optimo
OB. C. S. Ob Cives Servatos
OF. Officina.
OPEL. Opelius
ORB. TERR. Orbis Terrarum

P.

P. or POT. Potestate
PAC. ORB. TER. Pacatori Orbis Terrarum
PAPI. Papius or Papirius
PARTH. Parthicus
PERP. Perpetuus
PERT. or PERTIN. Pertinax
PESC. Pescennius
P. F. Pius Felix
PLAET. Plætonius
P. L. N. Pecunia Londini Notata
P. LON. S. Pecunia Londini Signata
P. M. or PONT. MAX. Pontifex Maximus
POMP. Pompeius
P. P. Pater Patriæ
PR. Prætor
P. R. Populus Romanus
PRAEF. CLAS. ET OR. MARIT. Præfectus Classis et Oræ Maritimæ
PRINC. IVVENT. Princeps Juventutis
PRIV. Privernum
PROC. Proconsul
PRON. Pronepos
PROP. Proprætor
PROQ. Proquæstor
PROV. DEOR. Providentia Deorum
PVPIEN. Pupienus

Q.

Q. Quintus, or Quæstor
Q. C. M. P. I. Quintus Cæcilius Metellus Pius Imperator
Q. DESIG. Quæstor Designatus
Q. P. Quæstor Prætorius
Q. PR. Quæstor Provincialis

R.

R. Roma, Restituit
RECEP. Receptis, or Receptus
REST. Restituti
ROM. ET AVG. Romæ et Augusto
R. P. Respublica

S.

SAEC. AVR. Sæculum Aureum
SAEC. FEL. Sæculi Felicitas
SAL. Salus
SALL. Sallustia
SARM. Sarmaticus
S. C. Senatus Consulto
SCIP. ASIA. Scipio Asiaticus
SEC. ORB. Securitas Orbis
SEC. PERP. Securitas Perpetua
SEC. TEMP. Securitas Temporum
SEN. Senior
SEPT. Septimius
SERV. Servius
SEV. Severus
SEX. Sextus.
SIC. V. SIC. X. Sicut Quinquennalia, sic Decennalia
SIG. Signis
S. M. Signata Moneta
S. P. Q. R. Senatus Populusque Romanus
STABIL. Stabilita (terra)
SVL. Sulla

T.

T. Titus, Tribunus
TER. Terentius, or Tertium
TEMP. Temporum
TI. Tiberium
TR. or TREV. Treveris
TREB. Trebonianus
TR. MIL. Tribunus Militaris
TR. P. or TRIB. POT. Tribunicia Potestate

V.

V. Quintum
V. S. Vir Clarissimus
VESP. Vespasianus
VIB. Vibius
VICT. Victoria
VII. VIR. EPVL. Septemvir Epulonum
VIL. PVB. Villa Publica
VIRT. Virtus
VN. MR. Venerandæ Memoriæ
VOT. X. MVLT. XX. Votis Decennalibus Multiplicatis Vicennalibus

X.

X. Decem, Denarius
XV. VIR. SARR. FAC. Quindecim Vir Sacris Faciundis.

Abbreviations

Abbreviations on the Exergue; from Banduri and Monaldini. Pinkerton.

A. Officina Prima
ALE. Alexandria
AMB. Antiochensis Moneta Secundæ Officinæ
AN. ANT. ANTI. Antiochia
ANB. Antiochiæ Secunda Officinia: to ANH. Antiochiæ Octava Officina
A. P. L. (In officina) Prima percussa Lugduni
AQ. AQL. Aquileiæ
AQ. O. B. F. Aquileiæ Officina Secundæ Fabrica
AQ. P. S. Aquileiæ Pecunia Signata
A. AR. ARL. Arelate
A. SISC. Prima (in officina) Sisciæ
B. SIRM. Secunda Sirmii
B. S. L. C. Secunda Signata Lugduni
C. Θ. Constantinopoli Nona
COMOB. Conflata Moneta Obryzo. Only on gold or silver from a gold die
CON. Constantinopoli
CONOB. Conflata Obryzo. Only on gold
CONS. Constantinopoli
KART. Carthago
K. O. Carthaginensis Officina
L. LC. LVC. LVG. Lucduni, Lugduni
L. LON. Londini
L. P. Lugdunensis vel Londinensis Pecunia
LVC. P. S. Lugduni Pecunia Signata
MDPS. Mediolani Pecunia Signata
M. K. V. T. Moneta Kartaginensis Urbs (in officina) Tertia
M. L. Moneta Lugdunensis vel Londinensis
MOSTT. Moneta Officinæ Secundæ Treverorum
MSTR. Moneta Signata Treveris
O. Officina
OFF. III. CONST. Officina Tertia Constantinopoli
PARL. Percussa or Pecunia Arelate
PLON. Pecunia Londinensis
PLVG. Pecunia Lugdunensis
P. R. Pecunia Romana, or Percussa Romæ
P. T. Pecunia Treverensis
Q. AR. Quincta Arelatensis (officina)
R. RO. ROM. Romæ
RA. Ravennæ
ROPS. Romæ Pecunia Signata
S. AR. Signata Arelate
S. CONST. Signati Constantinopoli
SIS. Sisciæ
SS. P. Sisciensis Pecunia
SISC. V. Siscia Urbs
SMA. Signata Moneta Antiochiæ
S. M. HER. Signata Moneta Heracleæ
S. M. N. Signata Moneta Nicomediæ
S. M. R. Signata Moneta Romæ
S. T. Signata
TESOB. Tessalonicæ Officina Secunda
THEOPO. Theopoli
TR. Treveris
TROB. Treveris Officina Secunda

A List of Roman Colonies whose Coins remain; and Abbreviations on these Coins.

Abdera in Spain
Acci in Spain
Achulla in Africa
Ælia Capitolina in Judæa
Agrippina in Germany
Antiochia in Pisidia
——— in Syria
Apamea in Bithynia
Arna in Thessaly
Astigi in Spain
Balba in Mauritania Tingitana
Berytus in Phœnicia
Bilbilis in Spain
Bostra in Arabia
Bracara Augusta in Spain
Buthrotum in Epirus
Cabellio in Gaul
Cæsar-Augusta in Spain
Cæsarea in Palestine

Calagurris

Abbrevia-tions.

Calagurris in Spain
Calpe in Spain
Camalodunum in Britain
Carrhæ in Mesopotamia
Carteia in Spain
Carthago in Africa
Carthago Nova in Spain
Cascantum in Spain
Cassandria in Macedon
Celsa in Spain
Clunia in Spain
Coillu in Numidia
Comana in Cappadocia
Corinthus in Greece
Cremna in Pisidia
Culla in Thrace
Damascus in Cœlesyria
Dertosa in Spain
Deulton in Thrace
Dium in Macedon
Ebora in Spain
Edessa in Mesopotamia
Emerita in Spain
Emesa in Phœnicia
Ergavica in Spain
Germe in Galatia
Graccuris in Spain
Hadrumetum in Africa
Heliopolis in Cœlesyria
Hippo Regius in Africa
Iconium in Lycaonia
Ilerda in Spain
Illergavonia in Spain
Illeci in Spain
Iol in Mauritania
Italica in Spain
Lælia in Spain
Laodicea in Syria
Leptis in Africa
Lugdunum in Gaul
Neapolis in Palestine
Nemausus in Gaul
Nesibis in Mesopotamia
Norba Cæsarea in Mauritania
Obulco in Spain
Oea in Africa
Olba in Pamphylia
Osca in Spain
Osicarda in Spain
Panormus in Sicily
Parium in Mysia
Parlais in Lycaonia
Patricia (Corduba) in Spain
Pella in Macedon
Philippi in Macedon
Philippopolis in Arabia
Ptolemais in Phœnicia
Rhesæna in Mesopotamia
Romula (Hispalis) in Spain
Ruscino in Gaul
Sabaria in Hungary
Saguntum in Spain
Sebaste in Palestine
Segobriga in Spain
Sidon in Phœnicia
Singara in Mesopotamia
Sinope in Pontus
Stobi in Macedon
Tarraco in Spain
Thessalonica in Macedon
Traducta (Julia) in Spain
Troas in Phrygia
Turiaso in Spain
Tyana in Cappadocia
Tyrus in Phœnicia
Valentia in Spain
Vienna in Gaul
Viminacium in Mœsia
Utica in Africa

Abbreviations on Colonial Coins.

ACCI. Accitana Colonia, *Guadix in Spain*
ADI. Adjutrix *legio*
AEL. MVN. COEL. Ælium Municipium Cœla, *near Sestos on the Hellespont*
AST. Astigitana, *Eceja* in Andalusia
B. A. Braccara Augusti, *Brague in Portugal*
C. A. Cæsarea Antiochiæ
C. A. A. P. or PATR. Colonia Augusta Aroë Patrensis
CAB. Cabellio
C. A. BVT. Colonia Augusti Buthrotum, *in Epirus*
C. A. C. Colonia Augusta Cæsarea
C. A. I. Colonia Augusta Julia, *Cadiz*
C. A. E. Colonia Aug. Emerita, *Merida*
CAL. Calagurris, *Calahorra in Spain*
C. A. O. A. F. Colonia Antoniana Oea Aug. Felix, *Tripoli in Africa*
C. A. PI. MET. SID. Colonia Amelia Pia Metropolis Sidon
C. A. R. Colonia Augusta Rauracorum, or Colonia Asta Regia: Augst in Switzerland, or Ast near Xeres de la Frontera in Spain
C. C. A. Colonia Cæsarea Augusta, *Saragossa in Spain*
C. C. COL. LUG. Claudia Copia Colonia Lugdunensis
C. C. I. B. Colonia Campestris Julia Balba, *in Mauritania*
C. C. I. B. D. D. Colonia Campestris Julia Balba, Decreto Decurionum
C. C. I. H. P. A. Colonia Concordia Julia Hadrumetina, Pia Augusta
C. CIV. D. D. P. Corona Civica data Decreto Publico
C. C. N. A. Colonia Carthago Nova Augusta
C. C. N. C. D. D. Colonia Concordia, Norba Cæsareana, Decreto Decurionum
C. COR. Colonia Corinthus
C. C. T. Ducentesima Remissa
C. C. S. Colonia Claudia Sabaria, *in Hungary*
C. F. P. D. Colonia Flavia Pacensis Develtum, *Develtum in Thrace*
C. G. I. H. P. A. Colonia Gemella Julia Hadriana, Pariana, Augusta
C. I. C. A. Colonia Julia Concordia, Apamea
C. I. A. D. Colonia Julia Augusta Dertona, *Tortona near Milan*
C. I. AV. Colonia Julia Aug. *Cadiz*
C. I. AVG. F. SIN. Colonia Julia Augusta Felix Sinope
C. I. B. Colonia Julia Balba, *in Mauritania*
C. I. C. A. P. A. Colonia Julia Carthago Augusta Pia Antiqua, or Corinth, or Carthago Nova
C. I. CAL. Colonia Julia Calpe, *Gibraltar*
C. I. F. Colonia Julia Felix, *Cadiz*
C. I. G. A. Colonia Julia Gemella (c) Augusta
C. I. I. A. Colonia Immunis Illici Augusta, *Elche in Spain*
C. I. N. C. Colonia Julia Norba Cæsareana, or Alcantara: sometimes it means Col. Julia Nova Carthago
C. I. V. Colonia Julia Valentia, *Valencia in Spain.*
C. V. T. Colonia Victrix Tarraco
C. L. I. COR. Colonia Laus Julia Corinthus
C. L. I. N. AVG. Colonia Laus Julia Nova Augusta, *Laus or Lodi in Lucania*
C. M. L. Colonia Metropolis Laodicea, *in Cœlesyria*
CO. DAM. METRO. Colonia Damascus Metropolis
COHH. PRET. VII. P. VI. F. Cohortes Prætorianæ Septimum Piæ, Sextum Felices
COH. I. CR. Cohors prima Cretensis
COH. PRET. PHIL. Cohors Prætoriana Philippensium
COL. AEL. A. H. MET. Colonia Ælia Augusta Hadrumetina Metropolis, *in Africa*
COL. AEL. CAP. COMM. P. F. Colonia Ælia Capitolina Commodiana Pia Felix
COL. ALEX TROAS. Colonia Alexandriana Troas
COL. AMAS. or AMS. Colonia Amastriana, *in Paphlagonia*
COL. ANT. *Antioch in Pisidia*
COL. ARELAT. SEXTAN. Colonia Arelate Sextanorum, *Arles*
COL. AST. AVG. Colonia Astingitana Augusta, *Eceja in Spain*

COL.

(c) Gemella implies a colony drawn from two others.

Abbreviations.

COL. AVG. FEL. BER. Colonia Augusta Felix Berytus

COL. AVG. FIR. Colonia Aug. Firma, *Eceja*

COL. AVG. IVL. PHILIP. Colonia Augusta Julia Philippensis

COL. AVG. PAT. TREVIR. Colonia Augusta Paterna Trevirorum, *Trêves in Germany, sent from Paternum in Italy*

COL. AVR. KAR. COMM. P. F. Colonia Aurelia Karrhæ Commodiana Pia Felix, or Carneatum Commagene, or *Carrhæ in Asia*

COL. B. A. Colonia Braccara Augusta, *Braguc*

COL. BRYT. L. V. Colonia Berytus Legio Quinta

COL. CABE. Colonia Cabellio

COL. CAES. AVG. Colonia Cæsarea Augusta, *in Palestine*

COL. CAMALODVN. Colonia Camalodunum, *England*

COL. CASILIN. Colonia Casilinum, *Castellazo in Italy*

COL. CL. PTOL. Colonia Claudia Ptolemais, *Acre in Phœnicia*

COL. DAMAS. METRO. Colonia Damascus Metropolis

COL. F. I. A. P. BARCIN. Colonia Flavia Julia Augusta Pia, Barcino *or Barcelona*

COL. FL. PAC. DEVLT. Colonia Flavia Pacensis Deultum, *Develtum in Thrace*

COL. HA. ME. T. Colonia Hadriana Mercurialis Thænitana, Mercuriali, *Fermo in Italy and Thenes in Africa*

COL. H. (or HEL.) LEG. H. Colonia Heliopolis Legio Heliopolitana

COL. HEL. I. O. M. H. Colonia Heliopolis Jovi Optimo Maximo Heliopolitano

COL. IVL. AVG. C. I. F. COMAN. Colonia Julia Augusta Concordia Invicta Felix Comanorum, *drawn from Concordia in Italy, and sent to Comana in Cappadocia*

COL. IVL. AVG. FEL. CREMNA. Colonia Julia Augusta Felix Cremna, *in Pamphylia*

COL. IVL. CER. SAC. AVG. FEL. CAP. OECVM. ISE. HEL. Colonia Julia Certamen Sacrum Augustum Felix Capitolenum Occumenicum Iselasticum Heliopolitanum

COL. IVL. CONC. APAM. AVG. D. D. Colonia Julia Concordia Apamea Augusta Decreto Decurionum

COL. IVL. PATER. NAR. Colonia Julia Paterna Narbonensis

COL. NEM. Colonia Nemausus

COL. NICEPH. COND. Colonia Nicephorium Condita, *in Mesopotamia*

COL. PATR. Colonia Patrensis *or* Patricia, *Patras in Greece*, or *Cordova in Spain*

COL. P. F. AVG. F. CAES. MET. Colonia Prima Flavia Aug. Felix Cæsarea Metropolis, *in Palestine*

COL. P. FL. AVG. CAES. METROP. P. S. P. *same as above*, P. S. P. *is* Provinciæ Syriæ Palestinæ

COL. PR. F. A. CAESAR. Colonia Prima Flavia Augusta Cæsarea, *in Palestine.*

COL. R. F. AVG. FL. C. METROP. Colonia Romana Felix Aug. Flavia Cæsarea Metropolis. *The same*

COL. ROM. Colonia Romulea, or *Seville*

COL. ROM. LVG. Colonia Romana Lugdunum

COL. RVS. LEG. VI. Colonia Ruscino Legio Sexta, *Rousillon in France*

COL. SABAR. Colonia Saburiæ

COL. SABAS. Sebaste, *in Palestine*

COL. SER. G. NEAPOL. Colonia Servii Galbæ Neapolis, *in Palestine*

COL. V. I. CELSA, or COR. VIC. IVL. CELSA. Colonia Victrix Julia Celsa, *Kelsa in Spain*

COL. VIC. IVL. LEP. Colonia Victrix Julia Leptis, *in Africa*

COL. VIM. AN. I. or II. &c. Colonia Viminacium Anno primo, *Widin in Servia*

COL. VLP. TRA. Colonia Ulpia Trajana: *Kellen*, or *Warhal in Transylvania*

CO. P. F. COE. METRO. Colonia Prima Flavia Cæsarea Metropolis

CO. P. I. A. Colonia Pacensis Julia Augusta, *or* Col. Octaviana

C. R. I. F. S. Colonia Romana Julia Felix Sinope

C. T. T. Colonia Togata Tarraco

C. V. IL. Colonia Victrix Illice, *Elche in Spain*

D. Decuriones

D. C. A. Divus. Cæs. Aug.

DERT. Dertosa

GEN. COL. NER. PATR. Genio Coloniæ Neronianæ Patrensis

G. L. S. Genio Loci Sacrum

M. A. ILLERGAVONIA DYRT. Municipium Hiberia Illergavonia Dertosa, *Tortosa in Catalonia*

M. M. I. V. Municipes Municipii Julii Uticensis

M. R. Municipium Ravennatium

MVN. CAL. IVL. Municipium Calagurris Julia, *in Spain*

MVN. CLVN. Municipium Clunia, *Corunna in Spain*

MVN. FANE. AEL. Municipium Fanestre Aelium, *Fano*

MVN. STOB. Municipium Stobense, *Stobi in Macedon*

MV. TV. Municipium Turiaso, *in Spain*

N. TR. ALEXANDRIANAE COL. BOSTR. Nerviæ Trajanæ Alexandrianæ Coloniæ Bostræ, *in Palestine*

SEP. COL. LAVD. Septimia Colonia Laudicea *or* Laodicea

SEP. TYR. MET. Septima Tyrus Metropolis.

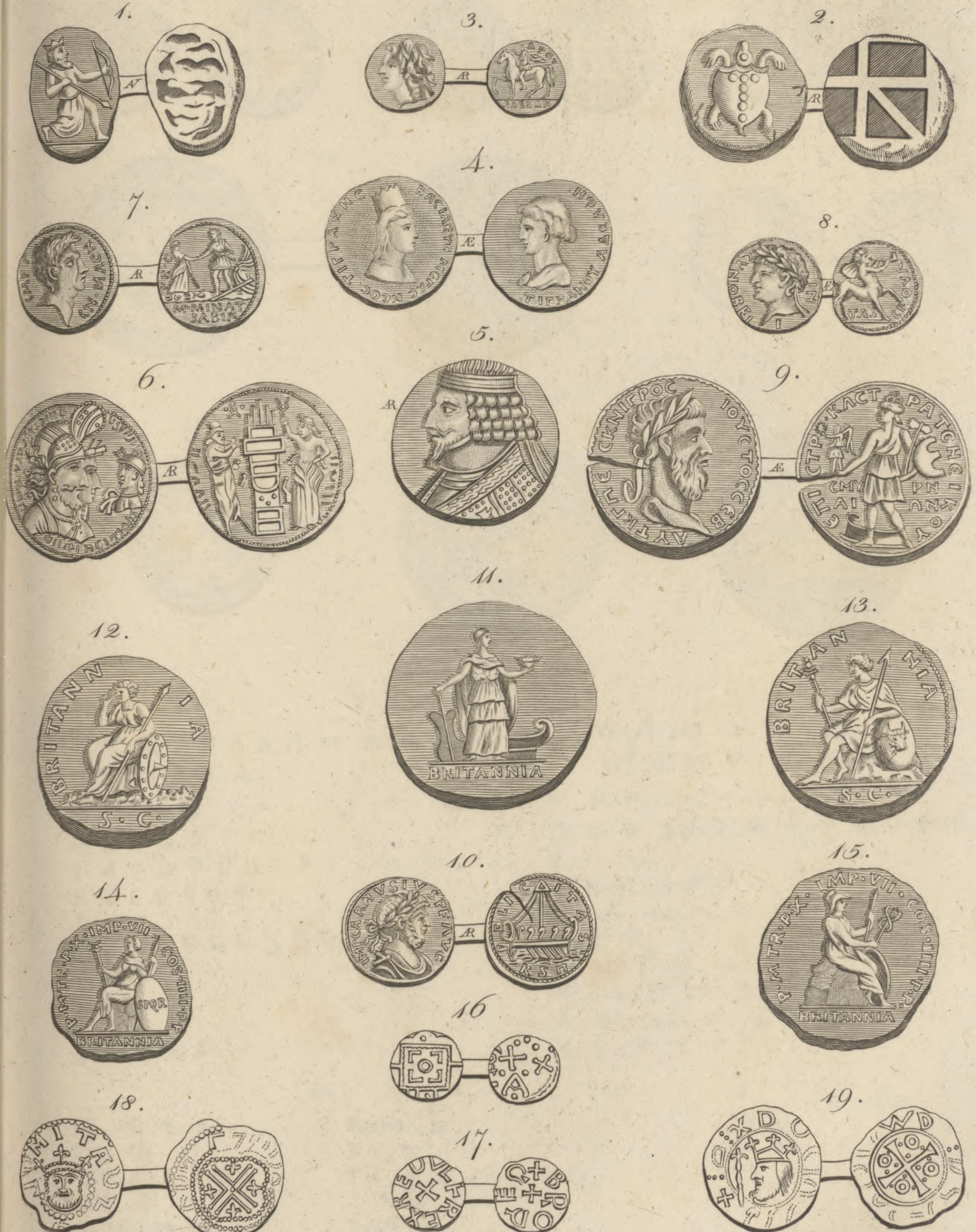
Explanation of Plates.

Explanation of the Plates.

Plat cccxx and cccxx

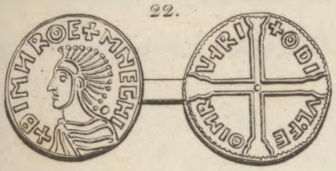
Fig. 1. A Persian daric
2. A drachm of Egina
3. A silver hemidrachm of Alexander the Great
4. Tigranes the younger of Armenia, with his sister
5. One of the coins of the Arsacidæ of Parthia
6. A coin of the Sassanidæ of Persia. First published by Mr Pinkerton
7. Denarius of Cneius Pompey from Mr Pinkerton. Reverse represents him as received by Spain
8. A brass coin of Cunobelinus
9. Pescennius Niger. Struck at Antioch; unique. In Dr Hunter's cabinet; published by Mr Pinkerton
10. A silver coin of Carausius
11. Reverse of Claudius in first brass
12. Reverse of Adrian
13. Of Antoninus Pius
14. Of Commodus
15. Of Severus
16. A Saxon penny
17. A Saxon styca
18. 19. Ancient pennies, supposed to be Scottish
20. A penny of William of Scotland
21. A penny of Robert the Great
22. An Irish penny

23. The



A.Bell Prin. Wal. Sculptor fecit

22.



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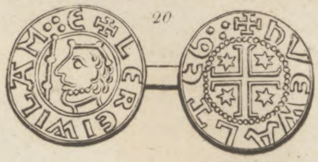

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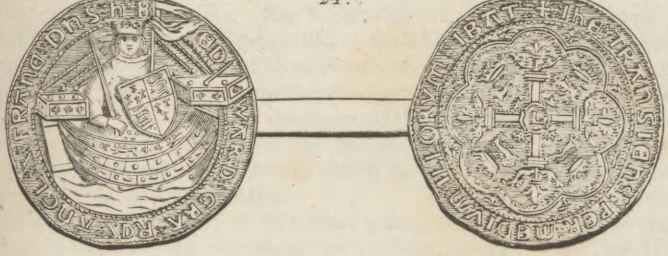

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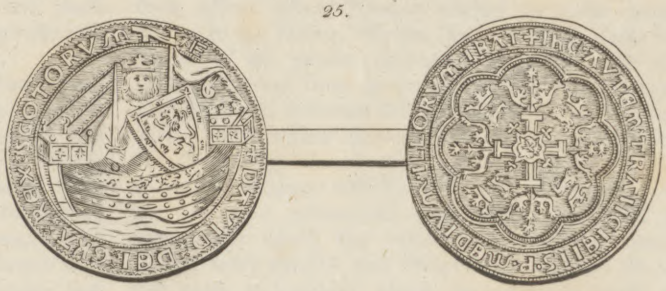

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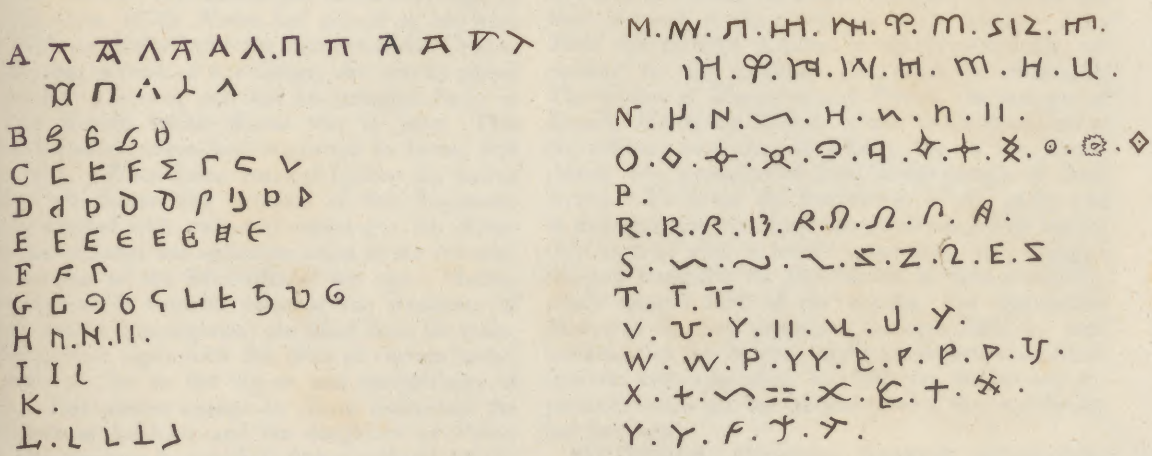

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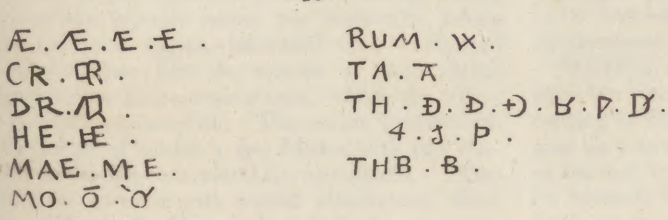

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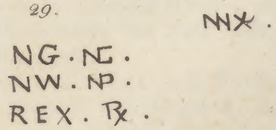

E. Mitchell Sculp[t]

Explanation of Plates.

23. The gold penny of Henry III.
24. The large noble of the first coinage of Edward III.
25. The gold medal of David II. of Scotland
26. The ryal of Queen Mary of Scotland
27. Letters on Anglo-Saxon coins
28. Abbreviations on ditto
29. Monetarius

Medals || Medea.

Impressions of Medals. See Casting.

MEDALLION, or Medalion, a medal of an extraordinary size, supposed to be anciently struck by the emperors for their friends, and for foreign princes and ambassadors. But, that the smallness of their number might not endanger the loss of the devices they bore, the Romans generally took care to stamp the subject of them upon their ordinary coins.

Medallions, in respect of the other coins, were the same as modern medals in respect of modern money: they were exempted from all commerce, and had no other value than what was set upon them by the fancy of the owner. Medallions are so scarce, that there cannot be any set made of them, even though the metals and sizes should be mixed promiscuously.

MEDEA, in fabulous history, a celebrated sorceress, daughter of Æetes king of Colchis. Her mother's name, according to the more received opinion of Hesiod and Hyginus, was Idyia, or, according to others, Ephyre, Hecate, Asterodia, Antiope, and Neæra. She was the niece of Circe. When Jason came to Colchis in quest of the golden fleece, Medea became enamoured of him, and it was to her well directed labours that the Argonauts owed their preservation. Medea had an interview with her lover in the temple of Hecate; where they bound themselves by the most solemn oaths to eternal fidelity. No sooner had Jason overcome all the difficulties which Æetes had placed in his way, than Medea embarked with the conquerors for Greece. To stop the pursuit of her father, she tore to pieces her brother Absyrtus, and left his mangled limbs in the way through which Æetes was to pass. This act of barbarity, some have attributed to Jason, and not to her. When Jason reached Iolchos his native country, the return and victories of the Argonauts were celebrated with universal rejoicings: but Æson the father of Jason was unable to assist at the solemnity on account of the infirmities of his age. Medea, at her husband's request, removed the weakness of Æson; and by drawing away the blood from his veins, and filling them again with the juice of certain herbs, she restored him to the vigour and sprightliness of youth. This sudden change in Æson astonished the inhabitants of Iolchos; and the daughters of Pelias were also desirous to see their father restored by the same power to the vigour of youth. Medea, willing to revenge the injuries which her husband's family had suffered from Pelias, increased their curiosity; and betrayed them into the murder of their father as preparatory to his rejuvenescence, which she afterwards refused to accomplish. This action greatly irritated the people of Iolchos; and Medea with her husband fled to Corinth to avoid their resentment. Here they lived for 10 years with mutual attachment, when the love of Jason for Glauce the king's daughter interrupted their harmony, and Medea was divorced. Medea revenged the infidelity of Jason, by causing the death of Glauce, and the destruction of her family. She also killed two of her children in their father's presence; and when Jason attempted to punish the barbarity of the mother, she fled through the air upon a chariot drawn by winged dragons. From Corinth Medea came to Athens, where, after she had undergone the necessary purification of her murder, she married King Ægeus, or (according to others) lived in an adulterous manner with him. From her conduct with Ægeus, Medea had a son who was called *Medus.* Soon after, when Theseus wished to make himself known to his father, Medea, jealous of his fame and fearful of his power, attempted to poison him at a feast which had been prepared for his entertainment. Her attempts, however, failed of success, and the sight of the sword which Theseus wore by his side convinced Ægeus that the stranger against whose life he had so basely conspired was his own son. The father and the son were reconciled; and Medea, to avoid the punishment which her wickedness deserved, mounted her fiery chariot and disappeared through the air. She came to Colchis; where, according to some, she was reconciled to Jason, who had sought her in her native country after her sudden departure from Corinth. She died at Colchis, as Justin mentions, when she had been restored to the confidence of her family. After death she married Achilles in the Elysian fields, according to the tradition mentioned by Simonides. The murder of Mermerus and Pheres, the youngest of Jason's children by Medea, is not to be attributed to the mother, according to Elian; but to the Corinthians, who assassinated them in the temple of Juno Acræa. To avoid the resentment of the gods, and to deliver themselves from the pestilence which visited their country after so horrid a massacre, they engaged the poet Euripides for five talents to write a tragedy, which cleared them of the murder, and represented Medea as the cruel assassin of her own children. And besides, that this opinion might be the better credited, festivals were appointed, in which the mother was represented with all the barbarity of a fury murdering her own sons.

Medea || Media.

MEDEOLA, Climbing African Asparagus, a genus of plants belonging to the hexandria class, and in the natural method ranking under the 11th order, *Sarmentaceæ*. See Botany *Index*.

MEDIA, now the province of Ghilan in Persia, once the seat of a potent empire, was bounded, according to Ptolemy, on the north by part of the Caspian sea; on the south by Persia, Susiana, and Assyria; on the east by Parthia and Hyrcania; and on the west by Armenia Major. It was anciently divided into several provinces, viz. Tropatene, Charomithrene, Darites, Media.

rites, Marciane, Amariace, and Syro Media. By a later division, however, all these were reduced to two; the one called *Media Magna*, the other *Media Atropatia*, or simply *Atropatene*. Media Magna was bounded by Persis, Parthia, Hyrcania, the Hyrcanian sea, and Atropatene, and contained the cities of Ecbatan, Laodicea, Apamea, Raga, Rageia or Ragea, &c. Atropatene lay between the Caspian mountains and the Caspian sea.

This country originally took its name from Madai, the third son of Japhet; as is plain from Scripture, where the Medes are constantly called *Madai*. Among profane authors, some derive the name *Media*, from one Medus the son of Jason and Medea; others from a city called *Media*. Sextus Rufus tells us that in his time it was called *Medena*, and from others we learn that it was also called *Aria*. The most probable history of the Medes is as follows:

This people lived in subjection to the Assyrians till the reign of Sennacherib, when they threw off the yoke, and lived for some time in a state of anarchy. But at last, rapine and violence, the natural consequences of such a situation, prevailed so much, that they were constrained to have recourse to some kind of government, that they might be enabled to live in safety. Accordingly, about 699 B. C. one Dejoces having procured himself to be chosen king, united the scattered tribes into which the Medes were at that time divided; and having applied himself as much as possible to the civilization of his barbarous subjects, left the throne to his son Phraortes, after a reign of 53 years.

The new king, who was of a warlike and enterprising disposition, subdued almost all the Upper Asia lying between Mount Taurus and the river Halys which runs through Cappadocia into the Euxine sea. Elated with this good success, he invaded Assyria, the empire of which was now much declined, and greatly weakened by the revolt of many nations which had followed the example of the Medes. Nebuchadonosor or Chyniladan, however, the reigning prince, having assembled what forces he could, engaged Phraortes, defeated, took him prisoner, and put him to death; after which, entering Media, he laid waste the country, took the metropolis of Ecbatan itself, and levelled it with the ground.

On the death of Phraortes, his son Cyaxares was placed on the throne. He was no less valiant and enterprising than his father, and had better success against the Assyrians. With the remains of that army which had been defeated under his father, he not only drove the conquerors out of Media, but obliged Chyniladan to shut himself up in Nineveh. To this place he immediately laid close seige; but was obliged to give over the enterprise on account of an irruption of the Scythians into his own country. Cyaxares engaged these new enemies with great resolution; but was utterly defeated; and the conquerors overran not only all Media, but the greatest part of Upper Asia, extending their conquests into Syria, and as far as the confines of Egypt. They continued masters of all this vast tract of country for 28 years, till at last Media was delivered from their yoke by a general massacre at the instigation of Cyaxares.

Media || Medicinal Springs.

After this deliverance, the Medes soon repossessed themselves of the territories they had lost; and once more extended their frontiers to the river Halys, their ancient boundary to the westward. After this we find the Medes engaged in a war with the Lydians; which, however, ended without any remarkable transaction: but on the conclusion of it, Cyaxares having entered into a strict alliance with Nebuchadnezzar king of Babylon, returned in conjunction with the Babylonians before Nineveh: which they took and levelled with the ground, putting most of the inhabitants to the sword.

After this victory the Babylonian and Median empires seem to have been united: however, after the death of Nebuchadnezzar, or rather in his lifetime, a war ensued, which was not extinguished but by the dissolution of the Babylonian empire. The Medes, under Astyages the son of Cyaxares I. withstood the power of the Babylonian monarchs: and under Cyrus and Cyaxares II. utterly destroyed their empire by the taking of BABYLON, as is related under that article. After the death of Cyaxares, the kingdom fell to Cyrus, by whom the seat of the empire was transferred to PERSIA, under which article the history of Media now falls to be considered, as also the manners, &c. of the inhabitants.

MEDIANA, the name of a vein or little vessel, made by the union of the cephalic and basilic, in the bend of the elbow.

MEDIASTINUM, in *Anatomy*, a double membrane, formed by a duplicature of the pleura; serving to divide the thorax and the lungs into two parts, and to sustain the viscera, and prevent their falling from one side of the thorax to the other. See ANATOMY, N° 117.

MEDIATE, or INTERMEDIATE, something that stands betwixt and connects two or more terms considered as extremes; in which sense it stands opposed to *immediate*.

MEDIATOR, a person that manages or transacts between two parties at variance, in order to reconcile them. The word, in Scripture, is applied, 1. To Jesus Christ, who is the only intercessor and peace-maker between God and man, (1 Tim. ii. 5.) 2. To Moses, who interposed between the Lord and his people, to declare unto them his word; (Deut. v. 5. iii. 19.).

MEDICAGO, SNAIL TREFOIL, a genus of plants belonging to the diadelphia class, and in the natural method ranking under the 32d order, *Papilionaceæ*. See BOTANY *Index*. For the properties and culture of LUCERN, a species of this genus, see AGRICULTURE *Index*.

MEDICINAL, any thing belonging to medicine.

MEDICINAL Springs, a general name for any fountain, the waters of which are of use for removing certain disorders. They are commonly either chalybeate or sulphureous. See SPRINGS and WATER.

MEDICINE.

Definition.

MEDICINE is the art of preventing, curing, or alleviating, those diseases to which the human species are subjected.

History of Medicine.

Origin of medicine among the Jews;

THE fabulous history of the ancients derives this art immediately from their gods; and, even among the moderns, some are of opinion that it may justly be considered as of divine revelation. But without adopting any supposition of which no probable evidence can be given, we may conclude, that mankind were naturally led to it from casual observation on the diseases to which they found themselves subjected; and that therefore, to a certain degree at least, it is as ancient as the human race. But at what period it began to be practised as an art, by particular individuals following it as a profession, is not known. The most ancient physicians we read of were those who embalmed the patriarch Jacob by order of his son Joseph. The sacred writer styles these physicians *servants* to Joseph: whence we may be assured that they were not *priests*, as the first physicians are generally supposed to have been; for in that age we know the Egyptian priests were in such high favour, that they retained their liberty, when, through a public calamity, all the rest of the people were made slaves to the prince.

It is not probable, therefore, that among the Egyptians religion and medicine were originally conjoined; and if we suppose the Jews not to have invented the art, but received it from some other nation, it is as little probable that the priests of that nation were their physicians as those of Egypt.

That the Jewish physicians were absolutely distinct from their priests is very certain. Yet as the Jews resided for such a long time in Egypt, it is probable they would retain many of the Egyptian customs, from which it would be very difficult to free them. We read, however, that when King Asa was diseased in his feet, "he sought not to the Lord, but to the physicians." Hence we may conclude, that among the Jews the medical art was looked upon as a mere human invention; and it was thought that the Deity never cured diseases by making people acquainted with the virtues of this or that herb, but only by his miraculous power. That the same opinion prevailed among the nations who were neighbours to the Jews, is also probable from what we read of Ahaziah king of Judah, who having sent messengers to inquire of Baalzebub god of Ekron concerning his disease, he did not desire any remedy from him or his priests, but simply to know whether he should recover or not.

What seems most probable on this subject therefore is, that religion and medicine came to be mixed together only in consequence of that degeneracy into ignorance and superstition which took place among all nations. The Egyptians, we know, came at last to be sunk in the most ridiculous and absurd superstition; and then, indeed, it is not wonderful that we should find their priests commencing physicians, and mingling charms, incantations, &c. with their remedies. That this was the case, long after the days of Joseph, we are very certain; and indeed it seems as natural for ignorance and barbarism to combine religion with physic, as it is for a civilized and enlightened people to keep them separate. Hence we see, that among all modern barbarians their priests or conjurors are their only physicians.

Origin of Medicine. 2 among the Egyptians;

We are so little acquainted with the state of physic among the Egyptians, that it is needless to say much concerning them. They attributed the invention of medicine, as they did also that of many other arts, to Thoth, the HERMES or MERCURY of the Greeks. He is said to have written many things in hieroglyphic characters upon certain pillars, in order to perpetuate his knowledge, and render it useful to others. These were transcribed by Agathodemon, or the second Mercury, the father of Tat, who is said to have composed books of them, that were kept in the most sacred places of the Egyptian temples. The existence of such a person, however, is very doubtful, and many of the books ascribed to him were accounted forgeries as long ago as the days of Galen; there is also great reason to suspect that those books were written many ages after Hermes, and when physic had made considerable advances. Many of the books attributed to him are trifling and ridiculous; and though sometimes he is allowed to have all the honour of inventing the art, he is on other occasions obliged to share it with Osiris, Isis, and Apis or Serapis.

After all, the Egyptian physic appears to have been little else than a collection of absurd superstitions. Origen informs us, that they believed there were 36 demons, or gods of the air, who divided the human body among them; that they had names for each of them; and that by invoking them according to the part affected, the patient was cured. Of natural medicines we hear none recommended by the father of Egyptian physic; except the herb *moly*, which he gave to Ulysses in order to secure him from the enchantments of Circe; and the herb *mercury*, of which he first discovered the use. His successors made use of venesection, cathartics, emetics, and clysters. There is no proof, however, that this practice was established by Hermes; on the contrary, the Egyptians themselves pretended that the first hint of those remedies was taken from some observations on brute animals. Venesection was taught them by the hippopotamus, which is said to perform this operation upon itself. On certain occasions, he comes out of the river, and strikes his leg against a sharp-pointed reed. As he takes care to direct the stroke against a vein, the consequence must be a considerable effusion of blood; and this being suffered to run as long as the creature thinks proper, he at last stops up the orifice with mud. The hint of clysters was taken from the ibis, a bird which is said to give itself clysters with its bill, &c. They used venesection, however, but very little, probably on account of the

Origin of Medicine. warmth of the climate; and the exhibition of the remedies above mentioned, joined with abstinence, formed the most of their practice.

3 Among the Greeks. The Greeks too had several persons to whom they attributed the invention of physic, particularly Prometheus, Apollo or Pæan, and Æsculapius; which last was the most celebrated of any. But here we must observe, that as the Greeks were a very warlike people, their physic seems to have been little else than what is now called *surgery*, or the cure of wounds, fractures, &c. Hence Æsculapius, and his pupils Chiron, Machaon, and Podalirius, are celebrated by Homer only for their skill in curing these, without any mention of their attempting the cures of internal diseases. We are not, however, to suppose that they confined themselves entirely to surgery. They no doubt would occasionally prescribe for internal disorders; but as they were most frequently conversant with wounds, we may naturally suppose the greatest part of their skill to have consisted in knowing how to cure these. If we may believe the poets, indeed, the knowledge of medicine seems to have been very generally diffused. Almost all the heroes of antiquity are reported to have been physicians as well as warriors. Most of them were taught physic by the centaur Chiron. From him Hercules received instructions in the medicinal art, in which he is said to have been no less expert than in feats of arms. Several plants were called by his name; from which some think it probable that he found out their virtues, though others are of opinion that they bore the name of this renowned hero on account of their great efficacy in removing diseases. Aristæus king of Arcadia was also one of Chiron's scholars; and is supposed to have discovered the use of the drug called *silphium*, by some thought to be asafœtida. Theseus, Telamon, Jason, Peleus, and his son Achilles, were all renowned for their knowledge in the art of physic. The last is said to have discovered the use of verdegrise in cleansing foul ulcers. All of them, however, seem to have been inferior in knowledge to Palamedes, who hindered the plague from coming into the Grecian camp after it had ravaged most of the cities of the Hellespont, and even Troy itself. His method was to confine his soldiers to a spare diet, and to oblige them to use much exercise.

The practice of these ancient Greek physicians, notwithstanding the praises bestowed on them by their poets seems to have been very limited, and in some cases even pernicious. All the external remedies applied to Homer's wounded heroes were fomentations; while inwardly their physicians gave them wine, sometimes mingled with cheese scraped down. A great deal of their physic also consisted of charms, incantations, amulets, &c. of which, as they are common to all superstitious and ignorant nations, it is superfluous to take any farther notice.

In this way the art of medicine continued among the Greeks for many ages. As its first professors knew nothing of the animal economy, and as little of the theory of diseases, it is plain, that whatever they did must have been in consequence of mere random trials, or empiricism, in the strict and proper sense of the word. Indeed, it is evidently impossible that this or almost any other art could originate from another source than trials of this kind. Accordingly, we find, that some ancient nations were accustomed to expose their sick in temples, and by the sides of highways, that they might receive the advice of every one who passed. Among the Greeks, however, Æsculapius was reckoned the most eminent practitioner of his time, and his name continued to be revered after his death. He was ranked among the gods; and the principal knowledge of the medical art remained with his family to the time of Hippocrates, who reckoned himself the seventeenth in a lineal descent from Æsculapius, and who was truly the first who treated of medicine in a regular and rational manner.

4 Æsculapius.

5 Hippocrates. Hippocrates, who is supposed to have lived 400 years before the birth of Christ, is the most ancient author whose writings expressly on the subject of the medical art are preserved; and he is therefore justly considered as the father of physic. All the accounts which we have prior to this time, if not evidently fabulous, are at the utmost highly conjectural. Even the medical knowledge of Pythagoras, so much celebrated as a philosopher, can hardly be considered as resting on any other foundation. But from the time of Hippocrates, medicine, separated from philosophy and religion, seems to have assumed the form of a science, and to have been practised as a profession. It may not, therefore, be improper, to give a particular account of the state of medical science, as transmitted to us in his writings. The writings of Hippocrates, however, it may be remarked, are even more than preserved. Many things have been represented as written by Hippocrates which are probably spurious. Nor is it wonderful that attempts should have been made to increase the value of manuscripts, by attributing them to a name of such eminence. But although what are transmitted to us under the title of his works may have been written by different hands, yet the presumption is, that most, if not all of them, are of nearly as early a date, and contain the prevailing opinions of those times.

6 His writings.

According to the most authentic accounts, Hippocrates was a native of the island of Cos, and born in the beginning of the 88th Olympiad. In the writings transmitted to us as his, we find a general principle adopted, to which he gives the name of *Nature*. To this principle he ascribes a mighty power. "Nature (says he) is of itself sufficient to every animal. She performs every thing that is necessary to them, without needing the least instruction from any one how to do it." Upon this footing, as if Nature had been a principle endowed with knowledge, he gives her the title of *just*: and ascribes virtues or powers to her, which are her servants, and by means of which she performs all her operations in the bodies of animals; and distributes the blood, spirits, and heat, through all parts of the body, which by these means receive life and sensation. And in other places he tells us, that it is this faculty which gives nourishment, preservation, and growth, to all things.

His idea of nature.

The manner in which Nature acts, or commands her subservient power to act, is by attracting what is good and agreeable to each species, and by retaining, preparing, and changing it; and on the other side in rejecting whatever is superfluous or hurtful, after she has separated it from the good. This is the foundation of the doctrine of depuration, concoction, and crisis in fevers,

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fevers, so much insisted on by Hippocrates and many other physicians. He supposes also, that every thing has an inclination to be joined to what agrees with it, and to remove from every thing contrary to it; and likewise that there is an affinity between the several parts of the body, by which they mutually sympathize with each other. When he comes to explain what this principle called *nature* is, he is obliged to resolve it into *heat*, which, he says, appears to have something immortal in it.

8
Of the causes of diseases.

As far as he attempts to explain the causes of disease, he refers much to the humours of the body, particularly to the blood and the bile. He treats also of the effects of sleep, watchings, exercise, and rest, and all the benefit or mischief we may receive from them. Of all the causes of diseases, however, mentioned by Hippocrates, the most general are diet and air. On the subject of diet he has composed several books, and in the choice of this he was exactly careful; and the more so, as his practice turned almost wholly upon it. He also considered the air very much; he examined what winds blew ordinarily or extraordinarily; he considered the irregularity of the seasons, the rising and setting of stars, or the time of certain constellations; also the time of the solstices, and of the equinoxes; those days, in his opinion, producing great alterations in certain distempers.

9
His division of diseases.

He does not, however, pretend to explain how, from these causes, that variety of distempers arises which is daily to be observed. All that can be gathered from him with regard to this is, that the different causes above mentioned, when applied to the different parts of the body, produce a great variety of distempers. Some of these distempers he accounted *mortal*, others *dangerous*, and the rest easily *curable*, according to the cause from whence they spring, and the parts on which they fall. In several places also he distinguishes diseases, from the time of their duration, into *acute* or *short*, and *chronical* or *long*. He likewise distinguishes diseases by the particular places where they prevail, whether ordinary or extraordinary. The first, that is, those that are frequent and familiar to certain places, he called *endemic* diseases; and the latter, which raged extraordinarily, sometimes in one place, sometimes in another, which seized great numbers at certain times, he called *epidemic*, that is, *popular* diseases: and of this kind the most terrible is the plague. He likewise mentions a third kind, the opposite of the former; and these he calls *sporadic*, or straggling diseases: these last include all the different sorts of distempers which invade at any one season, which are sometimes of one sort, and sometimes of another. He distinguished between those diseases which are hereditary, or born with us, and those which are contracted afterwards; and likewise between those of a *kindly* and those of a *malignant* nature, the former of which are easily and frequently cured, but the latter give the physicians a great deal of trouble, and are seldom overcome by all their care.

Hippocrates remarked four stages in distempers; viz. the beginning of the disease, its augmentation, its state or height, and its declination. In such diseases as terminate fatally, death comes in place of the declination. In the third stage, therefore, the change is most considerable, as it determines the fate of the sick person; and this is most commonly done by means of a *crisis*. By this word he understood any sudden change in sickness, whether for the better or for the worse, whether health or death succeed immediately. Such a change, he says, is made at that time by *nature*, either absolving or condemning the patient. Hence we may conclude, that Hippocrates imagined diseases to be only a disturbance of the animal economy, with which Nature was perpetually at variance, and using her utmost endeavours to expel the offending cause. Her manner of acting on these occasions is to reduce to their natural state those humours whose discord occasions the disturbance of the whole body, whether in relation to their quantity, quality, mixture, motion, or any other way in which they become offensive. The principal means employed by nature for this end is what Hippocrates calls *concoction*. By this he understood the bringing the morbific matter lodged in the humours to such a state, as to be easily fitted for expulsion by whatever means nature may think most proper. When matters are brought to this pass, whatever is superfluous or hurtful immediately empties itself, or nature points out to physicians the way by which such an evacuation is to be accomplished. The crisis takes place either by bleeding, stool, vomit, sweat, urine, tumors or abscesses, scabs, pimples, spots, &c. But these evacuations are not to be looked upon as the effects of a true crisis, unless they are in considerable quantity; small discharges not being sufficient to make a crisis. On the contrary, small discharges are a sign that nature is depressed by the load of humours, and that she lets them go through weakness and continual irritation. What comes forth in this manner is crude, because the distemper is yet too strong; and while matters remain in this state, nothing but a bad or imperfect crisis is to be expected. This shows that the distemper triumphs, or at least is equal in strength to nature, which prognosticates death, or a prolongation of the disease. In this last case, however, nature often has an opportunity of attempting a new crisis more happy than the former, after having made fresh efforts to advance the concoction of the humours.—It must here be observed, however, that, according to Hippocrates, concoction cannot be made but in a certain time, as every fruit has a limited time to ripen; for he compares the humours which nature has digested to fruits come to maturity.

10
His opinion of a crisis.

The time required for concoction depends on the differences among distempers mentioned above. In those which Hippocrates calls *very acute*, the digestion or crisis happens by the fourth day; in those which are only *acute*, it happens on the 7th, 11th, or 14th day; which last is the longest period generally allowed by Hippocrates in distempers that are truly acute: though in some places he stretches it to the 20th or 21st, nay, sometimes to the 40th or 60th day. All diseases that exceed this last term are called *chronical*. And while in those diseases that exceed 14 days, he considers every fourth day as critical, or at least remarkable, by which we may judge whether the crisis on the following fourth day will be favourable or not; so in those which run from 20 to 40 he reckons only the sevenths, and in those that exceed 40 he begins to reckon by 20. Beyond the 120th he thinks that the number of days has no power over the crisis. They are

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are then referred to the general changes of the seasons; some terminating about the equinoxes; others about the solstices; others about the rising or setting of the stars of certain constellations; or if numbers have yet any place, he reckons by months, or even whole years. Thus (he says), certain diseases in children have their crisis in the seventh month after their birth, and others in their seventh or even in their 14th year.

Though Hippocrates mentions the 21st as one of the critical days in acute distempers, as already noticed; yet, in other places of his works, he mentions also the 20th. The reason he gives for this in one of those places of his work is, that the days of sickness were not quite entire. In general, however, he is much attached to the odd days: insomuch that in one of his aphorisms he tells us, "The sweats that come out upon the 3d, 5th, 7th, 9th, 11th, 14th, 17th, 21st, 27th, 31st, or 34th days, are beneficial; but those that come out upon other days signify that the sick shall be brought low, that his disease shall be very tedious, and that he shall be subjected to relapses." He further says, "That the fever which leaves the sick upon any but an odd day is usually apt to relapse." Sometimes, however, he confesses that it is otherwise; and he gives an instance of a salutary crisis happening on the sixth day. But these are very rare instances, and therefore cannot, in his opinion, overthrow the general rule.

Besides the crisis, however, or the change which determines the fate of the patient, Hippocrates often speaks of another, which only changes the species of the distemper, without restoring the patient to health; as when a vertigo is turned to an epilepsy, a tertian fever to a quartan, or to a continued, &c.

11 His accuracy in prognostics;

But what has chiefly contributed to procure the great respect generally paid to Hippocrates, is his industry in observing the most minute circumstances of diseases, and his exactness in nicely describing every thing that happened before, and every accident that appeared at the same time with them; and likewise what appeared to give ease, and what to increase the malady: which is what we call *writing the history of a disease.*—Thus he not only distinguished one disease from another by the signs which properly belonged to each; but by comparing the same sort of distemper which happened to several persons, and the accidents which usually appeared before and after, he could often foretel a disease before it began, and afterwards give a right judgment of the event of it. By this way of prognosticating, he came to be exceedingly admired: and this he carried to such a height, that it may justly be said to be his master-piece; and Celsus, who lived after him, remarks, that succeeding physicians, though they found out several new things relating to the management of diseases, yet were obliged to the writings of Hippocrates for all that they knew of signs.

From the look;

The first thing Hippocrates considered, when called to a patient, was his looks.—It was a good sign with him to have a visage resembling that of a person in health, and the same with what the sick man had before he was attacked by the disease. As it varied from this, so much the greater danger was apprehended. The following is the description which he gives of the looks of a dying man.—"When a patient (says he) has his nose sharp, his eyes sunk, his temples hollow, his ears cold and contracted, the skin of his forehead tense and dry, and the colour of his face tending to a pale green, or lead colour, one may pronounce for certain that death is very near at hand; unless the strength of the patient has been exhausted all at once by long watchings, or by a looseness, or being a long time without eating." This observation has been confirmed by succeeding physicians, who have, from him, denominated it the *Hippocratic face*. The lips hanging relaxed and cold, are likewise looked upon by Hippocrates as a confirmation of the foregoing prognostic. He also took his signs from the disposition of the eyes in particular. When a patient cannot bear the light; when he sheds tears involuntarily; when, in sleeping, some part of the white of the eye is seen, unless he usually sleeps after that manner, or has a looseness upon him: these signs, as well as the foregoing ones, prognosticate danger. The eyes deadened, as it were with a mist spread over them, or their brightness lost, likewise presages death, or great weakness. The eyes sparkling, fierce, and fixed, denote the patient to be delirious, or that he soon will be seized with a frenzy. When the patient sees any thing red, and like sparks of fire and lightning pass before his eyes, you may expect an hæmorrhagy; and this often happens before those crises which are to be attended by a loss of blood.

From t posture bed;

The condition of the patient is also shewn by his posture in bed. If you find him lying on one side, his body, neck, legs, and arms, a little contracted, which is the posture of a man in health, it is a good sign: on the contrary, if he lies on his back, his arms stretched out, and his legs hanging down, it is a sign of great weakness; and particularly when the patient slides or lets himself fall down towards the feet, it denotes the approach of death. When a patient in a burning fever is continually feeling about with his hands and fingers, and moves them up before his face and eyes as if he was going to take away something that passed before them; or on his bed-covering, as if he was picking or searching for little straws, or taking away some filth, or drawing out little flocks of wool; all this is a sign that he is delirious, and that he will die. Amongst the other signs of a present or approaching delirium he also adds this: When a patient who naturally speaks little begins to talk more than he used to do, or when one that talks much becomes silent, this change is to be reckoned a sort of delirium, or is a sign that the patient will soon fall into one. The frequent trembling or starting of the tendons of the wrist, presage likewise a delirium. As to the different sorts of delirium, Hippocrates is much more afraid of those that run upon mournful subjects, than such as are accompanied with mirth.

From spirati

When a patient breathes fast, and is oppressed, it is a sign that he is in pain, and that the parts above the diaphragm are inflamed. Breathing long, or when the patient is a great while in taking his breath, shows him to be delirious; but easy and natural respiration is always a good sign in acute diseases. Hippocrates depended much on respiration in making his prognostics; and therefore has taken care in several places to describe the different manner of a patient's breathing. Continual watchings in acute diseases, are signs of present pain, or a delirium near at hand.

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Hippocrates also drew signs from all excrements, whatever they are, that are separated from the body of man. His most remarkable prognostics, however, were from the urine. The patient's urine, in his opinion, is best when the sediment is white, soft to the touch, and of an equal consistence. If it continue so during the course of the distemper, and till the time of the crisis, the patient is in no danger, and will soon be well. This is what Hippocrates called *concocted urine*, or what denotes the concoction of the humours; and he observed, that this concoction of the urine seldom appeared thoroughly, but on the days of the crisis which happily put an end to the distemper. "We ought (said Hippocrates) to compare the urine with the purulent matter which runs from ulcers. As the pus, which is white, and of the same quality with the sediment of the urine we are now speaking of, is a sign that the ulcer is on the point of closing; so that which is clear, and of another colour than white, and of an ill smell, is a sign that the ulcer is virulent, and in the same manner difficult to be cured; the urines that are like this we have described are only those which may be named good; all the rest are ill, and differ from one another only in the degrees of more and less. The first never appear but when nature has overcome the disease; and are a sign of the concoction of humours, without which you cannot hope for a certain cure. On the contrary, the last are made as long as their crudity remains, and the humours continue unconcocted. Among the urines of this last sort, the best are reddish, with a sediment that is soft and of an equal consistence; which denotes, that the disease will be somewhat tedious, but without danger. The worst are those which are very red, and at the same time clear and without sediment; or that are muddy and troubled in the making. In urine there is often a sort of cloud hanging in the vessel in which it is received; the higher this rises, or the farther distant it is from the bottom, or the more different it is from the colour of the laudable sediment above mentioned, the more there is of crudity. That which is yellow, or of a sandy colour, denotes abundance of bile; that which is black is the worst, especially if it has an ill smell, and is either altogether muddy or altogether clear. That whose sediment is like large ground wheat, or little flakes or scales spread one upon another, or bran, presages ill, especially the last. The fat or oil that sometimes swims upon the top of the urine, and appears in a form something like a spider's web, is a sign of a consumption of the flesh and solid parts. The making of a great quantity of urine is the sign of a crisis, and sometimes the quality of it shows how the bladder is affected. We must also observe, that Hippocrates compared the state of the tongue with the urine; that is to say, when the tongue was yellow, and charged with bile, the urine he knew must of course be of the same colour; and when the tongue was red and moist, the urine was of its natural colour.

Among his prognostics from the excretions by stool are the following:—Those that are soft, yellowish, of some consistence, and not of an extraordinary ill smell, that answer to the quantity of what is taken inwardly, and that are voided at the usual hours, are the best of all. They ought also to be of a thicker consistence when the distemper is near the crisis; and it ought to be taken for a good prognostic, when some worms, particularly the round and long, are evacuated at the same time with them. The prognosis, however, may still be favourable, though the matter excreted be thin and liquid, provided it make not too much noise in coming out, and the evacuation be not in a small quantity nor too often; nor in so great abundance, nor so often, as to make the patient faint. All matter that is watery, white, of a pale green or red colour, or frothy and viscous, is bad. That which is blackish, or of a livid hue, is the most pernicious. That which is pure black, and nothing else but a discharge of black bile, always prognosticates very ill; this humour, from what part soever it comes, showing the ill disposition of the intestines. The matter that is of several different colours, denotes the length of the distemper; and, at the same time, that it may be of dangerous consequence. Hippocrates places in the same class the matter that is bilious or yellow, and mixed with blood, or green and black, or like the dregs or scrapings of the guts. The stools that consist of pure bile, or entirely of phlegm, he also looks upon to be very bad.

Matter ejected by vomiting ought to be mixed with bile and phlegm; where one of these humours only is observed, it is worse. That which is black, livid, green, or of the colour of a leek, indicates alarming consequences. The same is to be said of that which smells very ill; and if at the same time it be livid, death is not far off. The vomiting of blood is very often a mortal symptom.

Expectoration.

The spittings which give ease in diseases of the lungs and in pleurisies, are those that come up readily and without difficulty; and it is good if they be mixed at the beginning with much yellow: but if they apear of the same colour, or are red, a great while after the beginning of the distemper, if they are salt and acrimonious, and cause violent coughings, they are not good. Spittings purely yellow are bad; and those that are white, viscous, and frothy, give no ease. Whiteness is a good sign of concoction in regard to spittings; but they ought not at all to be viscous, nor too thick, nor too clear. We may make the same judgment of the excrements of the nose according to their concoction and crudity. Spittings that are black, green, and red, are of very bad consequence. In inflammations of the lungs, those that are mixed with bile and blood presage well if they appear at the beginning, but are bad if they arise not about the seventh day. But the worst sign in these distempers is, when there is no expectoration at all, and the too great quantity of matter that is ready to be discharged this way makes a rattling in the breast. After spitting of blood, the discharge of purulent matter then follows, which brings on a consumption, and at last death.

Sweat.

A kind good sweat is that which arises on the day of the crisis, and is discharged in abundance all over the body, and at the same time from all parts of the body, and thus carries off the fever: A cold sweat is alarming, especially in acute fevers, for in others it is only a sign of long continuance. When the patient sweats no where but on the head and neck, it is a sign that the disease will be long and dangerous. A gentle sweat in some particular part of the head and breast, for instance, gives no relief, but denotes the seat of the distemper, or the weakness of the part.

This

Hippocrates.

This kind of sweat was called by Hippocrates *ephidrosis*.

The hypochondria, or the abdomen in general ought always to be soft and even, as well on the right side as on the left. When there is any hardness or unevenness in those parts, or heat and swellings, or when the patient cannot endure to have it touched, it is a sign the intestines are indisposed.

From the pulse.

Hippocrates also inquired into the state of the pulse, or the beating of the arteries. The most ancient physicians, however, and even Hippocrates himself, for a long time, by this word understood the violent pulsation that is felt in an inflamed part, without putting the fingers to it. It is observed by Galen, and other physicians, that Hippocrates touches on the subject of the pulse more slightly than any other on which he treats. But that our celebrated physician understood something even on this subject, is easily gathered from several passages in his writings; as when he observes, that in acute fevers the pulse is very quick and very great; and when he makes mention, in the same place, of trembling pulses, and those that beat slowly. He likewise observes, that in some diseases incident to women, when the pulse strikes the finger faintly, and in a languishing manner, it is a sign of approaching death. He remarks also, in the *Coacæ Prænotiones*, that he whose vein, that is to say, whose artery of the elbow, beats, is just going to run mad, or else that the person is at that time very much under the influence of anger.

From this account of Hippocrates, it will appear, that he was not near so much taken up with reasoning on the phenomena of diseases, as with reporting them. He was content to observe these phenomena accurately, to distinguish diseases by them, and judged of the event by comparing them exactly together. For his skill in prognostics he was indeed very remarkable, as we have already mentioned, insomuch that he and his pupils were looked upon by the vulgar as prophets. What adds very much to his reputation is, that he lived in an age when physic was altogether buried in superstition, and yet he did not suffer himself to be carried away by it; on the contrary, on many occasions, he expresses his abhorrence of it.

Having thus seen in what Hippocrates makes the difference between health and sickness to consist, and likewise the most remarkable signs from whence he drew his prognostics, we must now consider the means he prescribed for the preservation of health, and the cure of diseases. One of his principal maxims was this, That, to preserve health, we ought not to overcharge ourselves with too much eating, nor neglect the use of exercise and labour. In the next place, That we ought by no means to accustom ourselves to too nice and exact a method of living; because those who have once begun to act by this rule, if they vary in the least from it, find themselvss very ill; which does not happen to those who take a little more liberty, and live somewhat more irregularly. Notwithstanding this, he does not neglect to inquire diligently into the articles which those who were in health used for food in his time. Here we cannot help taking notice of the prodigious disparity between the delicacy of the people in our days and in those of Hippocrates: for he takes great pains to tell the difference between the flesh of a dog, a fox, a horse, and an ass; which he would not have done if at that time they had not been used for victuals, at least by the common people. Besides these, however, Hippocrates speaks of all other kinds of provision that are now in use; for example, salads, milk, whey, cheese, flesh as well of birds as of four-footed beasts, fresh and salt fish, eggs, all kinds of pulse, and the different kinds of grain we feed on, as well as the different sorts of bread that are made of it. He also speaks very often of a sort of liquid food, or broth, made of barley-meal, or some other grain, which they steeped for some time, and then boiled in water. With regard to drink, he takes a great deal of pains to distinguish the good waters from the bad. The best, in his opinion, ought to be clear, light, without smell or taste, and taken out of the fountains that turn towards the east. The salt waters, those that he calls hard, and those that rise out of fenny ground, are the worst of all; he condemns also those that come from melted snow. But though Hippocrates makes all those distinctions, he advises those who are in health to drink of the first water that comes in their way. He speaks also of alum waters, and those that are hot; but does not enlarge upon their qualities. He advises to mix wine with an equal quantity of water: and this (he says) is the just proportion; by using which the wine will expel what is hurtful to the body, and the water will serve to temper the acrimony of the humours.

12 His maxims for the preservation of health.

Diet.

Exercise.

For those that are in health, and likewise for such as are sick, Hippocrates advises exercise. The books, however, which treat on this subject, M. Le Clerc conjectures to have been written by Herodicus, who first introduced gymnastic exercise into medicine, and who is said by Hippocrates himself to have killed several people by forcing them to walk while they were afflicted with fevers and other inflammatory disorders. The advices given in them consist chiefly in directions for the times in which we ought to walk, and the condition we ought to be in before it; when we ought to walk slowly, and when to run, &c.; and all this with design to bring the body down, or dissipate the humours. Wrestling, although a violent exercise, is numbered with the rest. In the same place also mention is made of a play of the hands and fingers, which was thought good for health, and called *chironomie;* and of another diversion which was performed round a sort of ball hung up, which they called *corycus*, and which they struck forward with both their hands.

Excretion.

With regard to those things which ought to be separated from, or retained in the human body, Hippocrates observes, that people ought to take great care not to load themselves with excrements, or keep them in too long; and besides the exercise above mentioned, which carries off one part of them, and which he prescribes chiefly on this account, he advises people to excite and rouse up nature when she flagged, and did not endeavour to expel the rest, or take care of the impediments by which she was resisted. For this reason he prescribed meats proper for loosening the belly; and when these were not sufficient, he directed the use of clysters and suppositories. For thin and emaciated persons he directed clysters composed only of milk and oily unctuous substances, which they mixed with a decoction

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coction of chick-pease; but for such as were plethoric, they only made use of salt or sea-water.

As a preservative against distempers, Hippocrates also advised the use of vomits, which he directed to be taken once or twice a month during the time of winter and spring. The most simple of these were made of a decoction of hyssop, with an addition of a little vinegar and salt. He made those that were of a strong and vigorous constitution take this liquor in a morning fasting; but such as were thin and weakly took it after supper.—Venery, in his opinion, is wholesome, provided people consult their strength, and do not pursue it to excess; which he finds fault with on all occasions, and would have excess avoided also in relation to sleep and watching. In his writings are likewise to be found several remarks concerning good and bad air; and he makes it appear that the good or bad disposition of this element does not depend solely on the difference of the climate, but on the situation of every place in particular. He speaks also of the good and bad effects of the passions, and recommends moderation in regard to them.

From what we have already related concerning the opinions of Hippocrates, it may naturally be concluded, that for the most part he would be contented with observing what the strength of nature is able to accomplish without being assisted by the physician. That this was really the case, may be easily perceived from a perusal of his books entitled, "Of epidemical distempers;" which are, as it were, journals of the practice of Hippocrates: for there we find him often doing nothing more than describing the symptoms of a distemper, and informing us what has happened to the patient day after day, even to his death or recovery, without speaking a word of any kind of remedy. Sometimes, however, he did indeed make use of remedies; but these were exceedingly simple and few, in comparison of what have been given by succeeding practitioners. These remedies we shall presently consider, after we have given an abridgement of the principal maxims on which his practice was founded.

His maxims for the cure of diseases.

Hippocrates asserted in the first place, That contraries, or opposites, are the remedies for each other; and this maxim he explains by an aphorism; in which he says, that evacuations cure those distempers which come from repletion, and repletion those that are caused by evacuation. So heat is destroyed by cold, and cold by heat, &c. In the second place, he asserted that physic is an addition of what is wanting, and a subtraction or retrenchment of what is superfluous: an axiom which is thus explained, that there are some juices or humours, which in particular cases ought to be evacuated, or driven out of the body, or dried up; and some others which ought to be restored to the body, or caused to be produced there again. As to the method to be taken for this addition or retrenchment, he gives this general caution, That you ought to be careful how you fill up, or evacuate, all at once, or too quickly, or too much; and that it is equally dangerous to heat or cool again on a sudden; or rather, you ought not to do it: every thing that runs to an excess being an enemy to nature. In the fourth place, Hippocrates allowed that we ought sometimes to dilate, and sometimes to lock up: to dilate, or open the passages by which the humours are voided naturally, when they are not sufficiently opened, or when they are closed; and, on the contrary, to lock up or straiten the passages that are relaxed, when the juices that pass there ought not to pass, or when they pass in too great quantity. He adds, that we ought sometimes to smooth, and sometimes to make rough; sometimes to harden, and sometimes to soften again; sometimes to make more fine or supple; sometimes to thicken; sometimes to rouse up, and at other times to stupify or take away the sense; all in relation to the solid parts of the body, or to the humours. He gives also this farther lesson, That we ought to have regard to the course the humours take, from whence they come, and whither they go; and in consequence of that, when they go where they ought not, that we make them take a turn about, or carry them another way, almost like the turning the course of a river: or, upon other occasions, that we endeavour if possible to recal, or make the same humours return back again; drawing upward such as have a tendency downward, and drawing downward such as tend upward. We ought also to carry off, by convenient ways, that which is necessary to be carried off; and not let the humours once evacuated enter into the vessels again. Hippocrates gives also the following instruction, That when we do any thing according to reason, though the success be not answerable, we ought not easily, or too hastily, to alter the manner of acting, as long as the reasons for it are yet good. But as this maxim might sometimes prove deceitful, he gives the following as a corrector to it: "We ought (says he) to mind with a great deal of attention what gives ease, and what creates pain; what is easily supported, and what cannot be endured." We ought not to do any thing rashly; but ought often to pause, or wait, without doing any thing: by this way, if you do the patient no good, you will at least do him no hurt.

These are the principal and most general maxims of the practice of Hippocrates, and which proceed upon the supposition laid down at the beginning, viz. that nature cures diseases. We next proceed to consider particularly the remedies employed by him, which will serve to give us further instructions concerning his practice. 14

His maxims respecting diet.

Diet was the first, the principal, and often the only remedy made use of by this great physician to answer most of the intentions above mentioned: by means of it he opposed the moist to dry, hot to cold, &c.; and what he looked upon to be the most considerable point was, that thus he supported nature, and assisted her to overcome the malady. The dietetic part of medicine was so much the invention of Hippocrates himself, that he was very desirous to be accounted the author of it; and the better to make it appear that it was a new remedy in his days, he says expressly, that the ancients had wrote almost nothing concerning the diet of the sick, having omitted this point, though it was one of the most essential parts of the art. 15

Diet in acute diseases.

The diet prescribed by Hippocrates for patients labouring under acute distempers, differed from that which he ordered for those afflicted with chronical ones. In the former, which require a more particular exactness in relation to diet, he preferred liquid food to that which was solid, especially in fevers. For these he used a sort of broth made of cleansed barley; and to this he gave the name of *ptisan*. The manner in which the ancients prepared a ptisan was as follows:

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They first steeped the barley in water till it was plumped up; and afterwards they dried it in the sun, and beat it to take off the husk. They next ground it; and having let the flour boil a long time in the water, they put it out into the sun, and when it was dry they pressed it close. It is properly this flour so prepared that is called *ptisan*. They did almost the same thing with wheat, rice, lentils, and other grain: but they gave these ptisans the name of the grain from whence they were extracted, as *ptisan of lentils*, *rice*, &c. while the ptisan of barley was called simply *ptisan*, on account of the excellency of it. When they wanted to use it, they boiled one part of it in 10 or 15 of water; and when it began to grow plump in boiling, they added a little vinegar, and a very small quantity of anise or leek, to keep it from clogging or filling the stomach with wind. Hippocrates prescribed this broth for women that have pains in their belly after delivery. "Boil some of this ptisan (says he), with some leek, and the fat of a goat, and give it to the woman in bed." This will not be thought very singular, if we reflect on what has been hinted above concerning the indelicate manner of living in those times. He preferred the ptisan to all other food in fevers, because it softened and moistened much, and was besides of easy digestion. If he was concerned in a continual fever, he would have the patient begin with a ptisan of a pretty thick consistence, and go on by little and little, lessening the quantity of barley-flour as the height of the distemper approached; so that he did not feed the patient but with what he called the *juice of the ptisan;* that is, the ptisan strained, where there was but very little of the flour remaining, in order that nature being discharged in part from the care of digesting the aliments, she might the more easily hold out to the end, and overcome the distemper, or the cause of it. With regard to the quantity, he caused the ptisan to be taken twice a-day by such patients as in health used to take two meals a-day, not thinking it convenient that those who are sick should eat oftener than when they were well. He also would not allow eating twice a-day to those who ate but once in that time when in health. In the paroxysm of a fever he gave nothing at all; and in all distempers where there are exacerbations, he forbade nourishment while the exacerbations continued. He let children eat more; but those who were grown up to man's estate, or were of an advanced age, less; making allowance, however, for the custom of each particular person, or for that of the country.

But though he was of opinion that too much food ought not to be allowed to the sick, he did not agree with some physicians who prescribed long abstinence, especially in the beginning of fevers. The reason he gave for this was, that the contrary practice weakened the patients too much during the first days of the distemper, by which means their physicians were obliged to allow them more food when the illness was at its height, which in his opinion was improper. Besides, in acute distempers, and particularly in fevers, Hippocrates made choice of refreshing and moistening nourishment; and amongst other things prescribed orange, melon, spinach, gourd, &c. This sort of food he gave to those that were in a condition to eat, or could take something more than a ptisan.

[15] Drink.

The drink he commonly gave to his patients was made of eight parts of water and one of honey. In some distempers he added a little vinegar; but besides these, they had another sort named κυκεων, or *mixture*. One prescription of this sort we find intended for a consumptive person; it consisted of rue, anise, celery, coriander, juice of pomegranate, the roughest red wine, water, flour of wheat and barley, with old cheese made of goats milk. Hippocrates did not approve of giving plain water to the sick; but though he generally prescribed the drinks above mentioned, he did not absolutely forbid the use of wine, even in acute distempers and fevers, provided the patients were not delirious nor had pains in their head. Besides, he took care to distinguish the wines proper in these cases; preferring to all other sorts white wine that was clear and had a great deal of water, with neither sweetness nor flavour.

Diet in chronical diseases.

These are the most remarkable particulars concerning the diet prescribed by Hippocrates in acute distempers; in chronical ones he made very much use of milk and whey; though we are not certain whether this was done on account of the nourishment expected from them, or that he accounted them medicines.

His m[ethod] respecting bathing.

There were many diseases for which he judged the bath was a proper remedy; and he takes notice of all the circumstances that are necessary in order to cause the patient receive benefit from it, among which the following are the principal. The patient that bathes himself must remain still and quiet in his place without speaking while the assistants throw water over his head or are wiping him dry; for which last purpose he desired them to keep sponges, instead of that instrument called by the ancients *strigil*, which served to rub off from the skin the dirt and nastiness left upon it by the unguents and oils with which they anointed themselves. He must also take care not to catch cold; and must not bathe immediately after eating and drinking, nor eat or drink immediately after coming out of the bath. Regard must also be had whether the patient has been accustomed to bathe while in health, and whether he has been benefited or hurt by it. Lastly, he must abstain from the bath when the body is too open, or too costive, or when he is too weak; or if he has an inclination to vomit, a great loss of appetite, or bleeds at the nose. The advantage of the bath, according to Hippocrates, consists in moistening and refreshing, taking away weariness, making the skin soft and the joints pliant; in provoking urine, and opening the other excretories. He allows two baths in a day to those who have been accustomed to it in health.

His [opinion] resp[ecting] exer[cise].

In chronical distempers Hippocrates approved very much of exercise, though he did not allow it in acute ones: but even in these he did not think that a patient ought always to lie in bed; but tells us, that "we must sometimes push the timorous out of bed, and rouse up the lazy."

His [opinion] resp[ecting] purg[ation].

When he found that diet and exercise were not sufficient to ease nature of a burden of corrupted humours, he was obliged to make use of other means, of which *purgation* was one. By this word he understood all the contrivances that are made use of to discharge the stomach and bowels; though it commonly signifies only

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only the evacuation by stool. This evacuation he imagined to be occasioned by the purgative medicines attracting the humours to themselves. When first taken into the body, he thought they attracted that humour which was most similar to them, and then the others, one after another.—Most of the purgatives used in his time were emetics also, or at least were very violent in their operation downwards. These were the white and black hellebore; the first of which is now reckoned among the poisons. He used also the Cnidian berries, cneorum peplium, thapsia; the juice of hippophaë, a sort of rhamnus; elaterium, or juice of the wild cucumber; flowers of brass, coloquintida, scammony, the magnesian stone, &c.

As these purgatives were all very strong, Hippocrates was extremely cautious in their exhibition. He did not prescribe them in the dog-days; nor did he ever purge women with child, and very seldom children or old people. He principally used purgatives in chronical distempers; but was much more wary in acute ones. In his books entitled "Of Epidemical Distempers," there are very few patients mentioned to whom he gave purgative medicines. He also takes notice expressly, that these medicines having been given in cases of the distempers of which he was treating, had produced very bad effects. We are not, however, from this to conclude, that Hippocrates absolutely condemned purging in acute distempers; for in some places he expressly mentions his having given them with success. He was of opinion, for instance, that purging was good in a pleurisy when the pain was seated below the diaphragm; and in this case he gave black hellebore, or some peplium mixed with the juice of *laserpitium*.

The principal rule Hippocrates gives with relation to purging is, that we ought only to purge off the humours that are concocted, and not those that are yet crude, taking particular care not to do it at the beginning of the distemper, lest the humours should be disturbed or stirred up, which happens pretty often. He was not, however, the first who remarked that it would be of ill consequence to stir the humours in the beginning of an acute distemper. The Egyptian physicians had before observed the same thing. By the *beginning* of a distemper, Hippocrates understood all the time from the first day to the fourth complete.

Hippocrates imagined that each purgative medicine was adapted to the carrying off some particular humour; and hence the distinction of purgatives into hydragogue, cholagogue, &c. which is now justly exploded. In consequence of this notion, he contended that we knew if a purgative had drawn from the body what was fit to be evacuated according as the patient was found well or ill upon it. If we found ourselves well, it was a sign that the medicine had effectually expelled the offending humour. On the contrary, if we were ill, he imagined, whatever quantity of humour came away, that the humour which caused the illness still remained; not judging of the goodness or badness of a purge by the quantity of matters that were voided by it, but by their quality and the effect that followed after it.

Vomits were also pretty much used as medicines by Hippocrates. We have already seen what those were which he prescribed to people in health by way of preventives. With regard to the sick, he sometimes advised them to the same, when his intentions were only to cleanse the stomach. But when he had a mind to recal the humours, as he termed it, from the inmost recesses of the body, he made use of brisker remedies. Among these was white hellebore; and this indeed he most frequently used to excite vomiting. He gave this root particularly to melancholy and mad people; and from the great use made of it in these cases by Hippocrates and other ancient physicians, the phrase *to have need of hellebore*, became a proverbial expression for being out of one's senses. He gave it also in defluxions, which come, according to him, from the brain, and throw themselves on the nostrils or ears, or fill the mouth with saliva, or that cause stubborn pains in the head, and a weariness or an extraordinary heaviness, or a weakness of the knees, or a swelling all over the body. He gave it to consumptive persons in broth of lentils, to such as were afflicted with the dropsy called *leucophlegmatia*, and in other chronical disorders. But we do not find that he made use of it in acute distempers, except in the cholera morbus, where he says he prescribed it with benefit. Some took this medicine fasting; but most took it after supper, as was commonly practised with regard to vomits taken by way of prevention. The reason why he gave this medicine most commonly after eating was, that by mixing with the aliments, its acrimony might be somewhat abated, and it might operate with less violence on the membranes of the stomach. With the same intention also he sometimes gave a plant called *sesamoides*, and sometimes mixed it with hellebore. Lastly, in certain cases he gave what he called *soft* or *sweet* hellebore. This term had some relation to the quality of the hellebore, or perhaps the quantity he gave.

When Hippocrates intended only to keep the body open, or evacuate the contents of the intestines, he made use of simples; as, for example, the herb mercury, or cabbage; the juice or decoction of which he ordered to be drank. For the same purpose he used whey, and also cows and asses milk; adding a little salt to it, and sometimes letting it boil a little. If he gave asses milk alone, he caused a great quantity of it to be taken, so that it must of necessity loosen the body. In one place he prescribes no less than nine pounds of it to be taken as a laxative, but does not specify the time in which it was to be taken. With the same intention he made use of suppositories and clysters. The former were compounded of honey, the juice of the herb mercury, of nitre, powder of colocynth, and other sharp ingredients, to irritate the anus. These they formed into a ball, or into a long cylindrical mass like a finger. The clysters he made use of for sick people were sometimes the same with those already mentioned as preventives for people in health. At other times he mixed the decoction of herbs with nitre, honey, and oil, or other ingredients, according as he imagined he could by that means attract, wash, irritate, or soften. The quantity of liquor he ordered was about 36 ounces; from which it is probable he did not intend that it should all be used at one time.

On some occasions Hippocrates proposed to purge the head alone. This practice he employed after purging the rest of the body, in an apoplexy, inveterate pains

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pains of the head, a certain sort of jaundice, a consumption, and the greatest part of chronical distempers. For that purpose he made use of the juices of several plants, as celery; to which he sometimes added aromatic drugs, making the patients snuff up this mixture into their nostrils. He used also powders compounded of myrrh, the flowers of brass, and white hellebore, which he caused them put up into the nose, to make them sneeze, and to draw the phlegm from the brain. For the same purpose also he used what he calls *tetragonon*, that is, "something having four angles;" but what this was, is now altogether unknown, and was so even in the days of Galen. The latter physician, however, conjectures it to be antimony, or certain flakes found in it.

In the distemper called *empyema* (or a collection of matter in the breast), he made use of a very rough medicine. He commanded the patient to draw in his tongue as much as he was able; and when that was done, he endeavoured to put into the hollow of the lungs a liquor that irritated the part, which raising a violent cough, forced the lungs to discharge the purulent matter contained in them. The materials that he used for this purpose were of different sorts; sometimes he took the root of arum, which he ordered to be boiled with a little salt, in a sufficient quantity of water and oil; dissolving a little honey in it. At other times, when he intended to purge more strongly, he took the flowers of copper and hellebore; after that he shook the patient violently by the shoulders, the better to loosen the pus. This remedy, according to Galen, he received from the Cnidian physicians; and it has never been used by the succeeding ones, probably because the patients could not suffer it.

20 His maxims respecting blood-letting.

Blood-letting was another method of evacuation pretty much used by Hippocrates. Another aim he had in this, besides the mere evacuation, was to divert or recal the course of the blood when he imagined it was going where it ought not. A third end of bleeding was to procure a free motion of the blood and spirits,

Hippocrates had also a fourth intention for bleeding, and this was refreshment. So in the iliac passion, he orders bleeding in the arm and in the head; to the end, says he, that the superior venter, or the breast, may cease to be overheated. With regard to this evacuation, his conduct was much the same as to purging, in respect of time and persons. We ought, says he, to let blood in acute diseases, when they are violent, if the party be lusty and in the flower of his age. We ought also to have regard to the time, both in respect to the disease and to the season in which we let blood. He also informs us, that blood ought to be let in great pains, and particularly in inflammations. Among these he reckons such as fall upon the principal viscera, as the liver, lungs, and spleen, as also the quinsy and pleurisy, if the pain of the latter be above the diaphragm. In these cases he would have the patients blooded till they faint, especially if the pain be very acute; or rather he advises that the orifice should not be closed till the colour of the blood alters, so that from livid it turn red, or from red livid. In a quinsy he blooded in both arms at once. Difficulty of breathing he also reckons among the distempers that require bleeding; and he mentions another sort of inflammation of the lungs, which he calls a swelling or tumor of the lungs arising from heat; in which case he advises to bleed in all parts of the body; and directs it particularly by the arms, tongue, and nostrils. To make bleeding the more useful in all pains, he directed to open the vein nearest the part affected; in a pleurisy he directs to take blood from the arm of the side affected; and for the same reason, in pains of the head, he directs the veins of the nose and forehead to be opened. When the pain was not urgent, and bleeding was advised by way of prevention, he directed the blood to be taken from the parts farthest off, with a design to divert the blood insensibly from the seat of pain. The highest burning fevers, which show neither signs of inflammation nor pain, he does not rank among those distempers which require bleeding. On the contrary, he maintains that a fever itself is in some cases a reason against bleeding. If any one, says he, has an ulcer in the head, he must bleed, *unless he has a fever*. He says further, those that lose their speech of a sudden must be blooded, unless they have a fever. Perhaps he was afraid of bleeding in fevers, because he supposed that they were produced by the bile and pituita, which grew hot, and afterwards heated the whole body, which is, says he, what we call *fever*, and which, in his opinion, cannot well be evacuated by bleeding. In other places also he looks upon the presence or abundance of bile to be an objection to bleeding; and he orders to forbear venesection even in a pleurisy, if there be bile. To this we must add, that Hippocrates distinguished very particularly between a fever which followed no other distemper, but was itself the original malady, and a fever which came upon inflammation. In the early ages of physic, the first only were properly called *fevers*: the others took their names from the parts affected; as *pleurisy*, *peripneumony*, *hepatitis*, *nephritis*, &c, which names signify that the pleura, the lungs, the liver, or the kidneys, are diseased, but do not intimate the fever which accompanies the disease. In this latter sort of fever Hippocrates constantly ordered bleeding, but not in the former. Hence, in his books on Epidemic Distempers, we find but few directions for bleeding in the acute distempers, and particularly in the great number of continual and burning fevers there treated of. In the first and third book we find but one single instance of bleeding, and that in pleurisy; in which too, he staid till the eighth day of the distemper. Galen, however, and most other commentators on Hippocrates, are of opinion that he generally blooded his patients plentifully in the beginning of acute disorders, though he takes no notice of it in his writings. But had this been the case, he would not perhaps have had the opportunity of seeing so many fevers terminate by crisis, or natural evacuations, which happen of themselves on certain days. Hippocrates, in fact, laid so much weight upon the assistance of nature and the method of diet, which was his favourite medicine, that he thought if they took care to diet the patients according to rule, they might leave the rest to nature. These are his principles, from which he never deviates; so that his writings on Epidemical Diseases seem to have been composed only with an intention to leave to posterity an exact model of management in pursuance of these principles.

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With regard to the rules laid down by Hippocrates for bleeding, we must farther take notice, that in all diseases which had their seat above the liver, he blooded in the arm, or in some of the upper parts of the body; but for those that were situated below it, he opened the veins of the foot, ankle, or ham. If the belly was too loose, and bleeding was at the same time thought necessary, he ordered the looseness to be stopped before bleeding.

Almost all these instances, however, regard scarcely any thing but acute distempers; but we find several concerning chronical diseases. "A young man complained of great pain in his belly, with a rumbling while he was fasting, which ceased after eating: this pain and rumbling continuing, his meat did him no good; but, on the contrary, he daily wasted and grew lean. Several medicines, as well purges as vomits, were given him in vain. At length it was resolved to bleed him by intervals, first in one arm and then in the other, till he had scarcely any blood left, and by this method he was perfectly cured."

Hippocrates let blood also in a dropsy, even in a tympany; and in both cases he prescribes bleeding in the arm. In a disease occasioned by an overgrown spleen, he proposes bleeding several times repeated at a vein of the arm which he calls the *splenetic;* and in one species of jaundice, he proposes bleeding under the tongue. On some occasions he took away great quantities of blood, as appears from what we have already observed. Sometimes he continued the blooding till the patient fainted: at other times he would blood in both arms at once; at others, he did it in several places of the body, and at several times. The veins he opened were those of the arm, the hands, the ankles on both sides, the hams, the forehead, behind the head, the tongue, the nose, behind the ears, under the breasts, and those of the arms; besides which, he burnt others, and opened several arteries. He likewise used cupping-vessels, with intent to recal or withdraw the humours which fell upon any part. Sometimes he contented himself with the bare attraction made by the cupping-vessels, but sometimes also he made scarifications.

21 H[is] maxims re[spe]cting di[ure]tics a[nd] sudo[rifics].

When bleeding and purging, which were the principal and most general means used by Hippocrates for taking off a plethora, proved insufficient for that purpose, he had recourse to diuretics and sudorifics. The former were of different sorts, according to the constitution of the persons: sometimes baths, and sometimes sweet wine, were employed to provoke urine; sometimes the nourishment which we take contributes to it: and amongst those herbs which are commonly eaten, Hippocrates recommends garlic, leeks, onions, cucumbers, melons, gourds, fennel, and all other things which have a biting taste and a strong smell. With these he numbers honey, mixed with water or vinegar, and all salt meats. But, on some occasions, he took four cantharides, and, pulling off their wings and feet, gave them in wine and honey. These remedies were given in a great number of chronical distempers after purging, when he thought the blood was overcharged with a sort of moisture which he calls *ichor;* or in suppressions of urine, and when it was made in less quantity than it ought. There were also some cases in which he would force sweat as well as urine; but he neither mentions the diseases in which sudorifics are proper, nor lets us know what medicines are to be used for this purpose, except in one single passage, where he mentions sweating, by pouring upon the head a great quantity of water till the feet sweat; that is, till the sweat diffuses itself over the whole body, running from head to foot. After this he would have them eat boiled meat, and drink pure wine, and being well covered with clothes, lay themselves down to rest. The disease for which he proposes the above-mentioned remedy is a fever; which is not, according to him, produced by bile or pituita, but by mere lassitude, or some other similar cause; from whence we may conclude that he did not approve of sweating in any other kind of fever.

Other remedies which Hippocrates tells us he made use of were those that purged neither bile nor phlegm, but act by cooling, drying, heating, moistening, or by closing and thickening, resolving and dissipating. These medicines, however, he does not particularly mention; and it is probable they were only some particular kinds of food. To these he joined *hypnotics*, or such things as procure sleep; but these last were used very seldom, and, it is most probable, were only different preparations of poppies.

22 The use he made of specifics.

Lastly, besides the medicines already mentioned, which acted in a sensible manner, Hippocrates made use of others called *specifics;* whose action he did not understand, and for the use of which he could give no reason but his own experience, or that of other physicians. These he had learned from his predecessors the descendants of Æsculapius, who, being *empirics*, did not trouble themselves about enquiring into the operation of remedies, provided the patients were cured.

23 His external applications.

Of the external remedies prescribed by Hippocrates, fomentations were the chief. These were of two kinds. The one was a sort of bath, in which the patient sat in a vessel full of a decoction of simples appropriated to his malady; so that the part affected was soaked in the decoction. This was chiefly used in distempers of the womb, of the arms, the bladder, the reins, and generally all the parts below the diaphragm. The second way of fomenting was, to take warm water and put it into a skin or bladder, or even into a copper or earthen vessel, and to apply it to the part affected; as, for example, in a pleurisy. They used likewise a large sponge, which they dipped in the water or other hot liquor, and squeezed out part of the liquor before they applied it. The same use they made of barley, vetches, or bran, which were boiled in some proper liquor, and applied in a linen bag. They are called *moist* fomentations. The dry ones were made of salt or millet, heated considerably, and applied to the part. Another kind of fomentation was the vapour of some hot liquor; an instance of which we find in the first book of the Distempers of Women. He cast, at several times, bits of red-hot iron into urine, and, covering up the patient close, caused her to receive the steam below. His design in these kinds of fomentations was to warm the part, to resolve or dissipate, and draw out the peccant matter, to mollify and assuage pain, to open the passages, or even to shut them, according as the fomentations were emollient or astringent.

24 Fomentations.

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25 Fumigations. Fumigations were likewise very often used by Hippocrates. In the quinsy, he burned hyssop with sulphur and pitch, and caused the smoke to be drawn into the throat by a funnel; and by this means he brought away abundance of phlegm through the mouth and through the nose. For this purpose he took nitre, marjoram, and cress-seeds, which he boiled in water, vinegar, and oil, and, while it was on the fire, caused the patient to draw in the steam by a pipe. In his works we find a great number of fumigants for the distempers of women, to promote the menstrual flux, to check it, to help conception, and to ease pains in the matrix, or the suffocation of it. On these occasions he used such aromatics as were then known, viz. cinnamon, cassia, myrrh, and several odoriferous plants; likewise some minerals, such as nitre, sulphur, and pitch, and caused the patient to receive the vapours through a funnel into the uterus.

26 Gargles. Gargles, a kind of fomentations for the mouth, were also known to Hippocrates. In the quinsy he used a gargle made of marjoram, savory, celery, mint, and nitre, boiled with water and a little vinegar. When this was strained, they added honey to it, and washed their mouths frequently with it.

27 Oils and ointments. Oils and ointments were likewise much used by Hippocrates, with a view to mollify and abate pain, to ripen boils, resolve tumours, refresh after weariness, make the body supple, &c. For this purpose, sometimes pure oil of olives was used; sometimes certain simples were infused in it, as the leaves of myrtle and roses; and the latter kind of oil was in much request among the ancients. There were other sorts of oils sometimes in use, however, which were much more compounded. Hippocrates speaks of one named Susinum, which was made of the flowers of the iris, of some aromatics, and of an ointment of narcissus made with the flowers of narcissus and aromatics infused in oil. But the most compounded of all his ointments was that called *netopon*, which he made particularly for women; and consisted of a great number of ingredients. Another ointment, to which he gave the name of *ceratum*, was composed of oil and wax. An ointment which he recommends for the softening a tumor, and the cleansing a wound, was made by the following receipt: "Take the quantity of a nut of the marrow or fat of a sheep, of mastic or turpentine the quantity of a bean, and as much wax; melt these over a fire, with oil of roses, for a ceratum." Sometimes he added pitch and wax, and, with a sufficient quantity of oil, made a composition somewhat more consistent than the former, which he called *cerapissus*.

28 Cataplasms. *Cataplasms* were a sort of remedies less consistent than the two former. They were made of powders or herbs steeped or boiled in water or some other liquor, to which sometimes oil was added. They were used with a view to soften or resolve tumors, ripen abscesses, &c. though they had also cooling cataplasms made of the leaves of beets or oak, fig or olive-trees, boiled in water.

29 Collyria. Lastly, To complete the catalogue of the external remedies used by Hippocrates, we shall mention a sort of medicine called *collyrium*. It was compounded of powders, to which was added a small quantity of some ointment, or juice of a plant, to make a solid or dry mass; the form of which was long and round, which was kept for use. Another composition of much the same nature was a sort of lozenge of the bigness of a small piece of money, which was burnt upon coals for a perfume, and powdered for particular uses. In his works we find likewise descriptions of powders for several uses, to take off fungous flesh, and to blow into the eyes in opthalmics, &c.

These were almost all the medicines used by Hippocrates for external purposes. The compound medicines given inwardly were either liquid, solid, or lambative. The liquid ones were prepared either by decoction or infusion in a proper liquor, which, when strained, were kept for use; or by macerating certain powders in such liquors, and so taking them together, or by mixing different kinds of liquors together. The solid medicines consisted of juices inspissated; of gums, resins, or powders, made up with them or with honey, or something proper to give the necessary consistence to the medicine. These were made up in a form and quantity fit to be swallowed with ease. The lambative was of a consistence between solid and fluid; and the patients were obliged to keep it for some time to dissolve in the mouth, that they might swallow it leisurely. This remedy was used to take off the acrimony of those humours which sometimes fall upon this part, and provoke coughing and other inconveniences. The basis of this last composition was honey. It is worth our observation, that the compound medicines of Hippocrates were but very few, and composed only of four or five ingredients at most; and that he not only understood pharmacy, or the art of compounding medicines, but prepared such as he used himself, or caused his servants prepare them in his house by his directions.

We have thus given some account of the state of medicine as practised and taught by Hippocrates, who, as we have already observed, has for many ages been justly considered as the father of physic. For when we attend to the state in which he found medicine, and the condition in which he left it, we can hardly bestow sufficient admiration on the judgment and accuracy of his observations. After a life spent in unwearied industry, he is said to have died at Larissa, a city in Thessaly, in the 101st year of his age, 361 years before the birth of Christ.

After the days of Hippocrates, medicine in ancient Greece gradually derived improvement from the labour of other physicians of eminence. And we may particularly mention three to whom its future progress seems to have been not a little indebted; viz. Praxagoras, Erasistratus, and Herophilus.

30 Praxagoras. The first physician of eminence who differed considerably in his practice from Hippocrates was Praxagoras. Cœlius Aurelianus acquaints us, that he made great use of vomits in his practice, insomuch as to exhibit them in the iliac passion till the excrements were discharged by the mouth. In this distemper he also advised, when all other means failed, to open the belly, cut the intestine, take out the indurated fæces, and then to sew up all again; but this practice has not probably been followed by any subsequent physician.

31 Erasistratus. Erasistratus was a physician of great eminence, and flourished in the time of Seleucus, one of the successors of Alexander the Great. According to Galen,

Erasistratus.

Galen, he entirely banished venesection from medicine; though some affirm that he did not totally discard it, but only used it less frequently than other physicians. His reasons for disapproving of venesection are as follow: It is difficult to succeed in venesection, because we cannot always see the vein we intend to open, and because we are not sure but we may open an artery instead of a vein. We cannot ascertain the true quantity to be taken. If we take too little, the intention is by no means answered: if we take too much, we run a risk of destroying the patient. The evacuation of the venous blood also is succeeded by that of the spirits, which on that occasion he supposes to pass from the arteries into the veins. It must likewise, he contends, be observed, that as the inflammation is formed in the arteries by the blood coagulated in their orifices, venesection must of course be useless and of no effect.

As Erasistratus did not approve of venesection, so neither did he of purgatives, excepting very rarely, but exhibited clysters and vomits; as did also his master Chrysippus. He was of opinion, however, that the clysters should be mild; and condemned the large quantity and acrid quality of those used by preceding practitioners. The reason why purgatives were not much used by him was, that he imagined purging and venesection could answer no other purpose than diminishing the fulness of the vessels; and for this purpose he assserted that there were more effectual means than either phlebotomy or purging. He asserted that the humours discharged by cathartics were not the same in the body that they appeared after the discharge; but that the medicines changed their nature, and produced a kind of corruption in them. This opinion has since been embraced by a great number of physicians. He did not believe that purgatives acted by attraction; but substituted in the place of this principle what Mr Le Clerc imagines to be the same with Aristotle's *fuga vacui*. The principal remedy substituted by him in place of purging and venesection was abstinence. When this, in conjunction with clysters and vomits, was not sufficient to eradicate the disease, he then had recourse to exercise. All this was done with a view to diminish plenitude, which, according to him, was the most frequent cause of all diseases. Galen also informs us, that Erasistratus had so great an opinion of the virtues of succory in diseases of the viscera and lower belly, and especially in those of the liver, that he took particular pains to describe the method of boiling it, which was, to boil it in water till it was tender; then to put it into boiling water a second time, in order to destroy its bitterness; afterwards to take it out of the water, and preserve it in a vessel with oil; and lastly, when it is to be used, add a little weak vinegar to it. Nay, so minute and circumstantial was Erasistratus with regard to the preparation of his favourite succory, that he gave orders to tie several of the plants together, because that was the more commodious method of boiling them. The rest of Erasistratus's practice consisted almost entirely of regimen; to which he added some topical remedies, such as catapsalms, fomentations, and unctions. In short, as he could neither endure compounded medicines, nor superstitious and fine-spun reasonings, he reduced medicine to a very simple and compendious art.

With regard to surgery, Erasistratus appears to have been very bold; and as an anatomist he is said to have been exceedingly cruel, insomuch that he is represented by some as having dissected criminals while yet alive *. In a scirrhous liver, or in tumours of that organ, Cœlius Aurelianus observes, that Erasistratus made an incision through the skin and integuments, and having opened the abdomen he applied medicines immediately to the part affected. But though he was thus bold in performing operations on the liver, yet he did not approve of the paracentesis or tapping in the dropsy; because (said he) the waters being evacuated, the liver, which is inflamed and become hard like a stone, is more pressed by the adjacent parts which the waters kept at a distance from it, so that by this means the patient dies. He declared also against drawing teeth which were not loose; and used to tell those who talked with him on this operation, That in the temple of Apollo there was to be seen an instrument of lead for drawing teeth; in order to insinuate that we must not attempt the extirpation of any but such as are loose, and call for no greater force for their extirpation than what may be supposed in an instrument of lead.

Herophilus.

* See Anatomy, *Hist.*

32 Herophilus.

Herophilus, the disciple of Praxagoras, and contemporary of Erasistratus, followed a less simple practice: he made so great use of medicines both simple and compound, that neither he nor his disciples would undertake the cure of any disorder without them. He seems also to have been the first who treated accurately of the doctrine of pulses, of which Hippocrates had but a superficial knowledge. Galen, however, affirms, that on this subject he involved himself in difficulties and advanced absurdities; which indeed we are not greatly to wonder at, considering the time in which he lived. He took notice of a disease at that time pretty rare, and to which he ascribes certain sudden deaths. He calls it a *palsy of the heart;* and perhaps it may be the same disease with what is now termed the *angina pectoris*.

According to Celsus, it was about this time that medicine was first divided into three branches, viz. the dietetic, the pharmaceutical, and the chirurgical medicine. The first of these employed a proper regimen in the cure of diseases; the second, medicines; and the third, the operation of the hands. The same author informs us, that these three branches became now the business of as many distinct classes of men; so that from this time we may date the origin of the three professions of physicians, apothecaries, and surgeons.—Before this division, those called *physicians* discharged all the several offices belonging to the three professions; and there were only two kinds of them, viz. one called αρχιτεκτονικοι, who gave only their advice to the patients, and directions to those of an inferior class, who were called δημιουργοι, and worked with their hands either in the performing operations, or in the composition and application of remedies.

33 The Empirics.

The first grand revolution which happened in the medicinal art, after the days of Herophilus and Erasistratus, was occasioned by the founding of the empiric sect by Serapion of Alexandria about 287 years before Christ. The division into dogmatists and empirics had indeed subsisted before; but about this time the latter party began to grow strong, and to have champions

34 Serapion.

Serapion.

pions publicly asserting its cause. Galen informs us, that Serapion used Hippocrates very ill in his writings, in which he discovered an excess of pride, self-sufficiency, and contempt for all the physicians that went before him. We have some sketches of his practice in Cœlius Aurelianus, from which we may infer that he retained the medicines of Hippocrates and the other physicians who went before him, though he rejected their reasoning. We know not what arguments he advanced for the support of his sentiments, since his works are lost, as well as those of the other empirics; and we should know nothing at all of any of them, if their adversaries had not quoted them in order to confute them.

The empirics admitted only one general method of obtaining skill in the medical art, which was by experience, called by the Greeks εμπειρια. From this word they took their name, and refused to be called after the founder or any champion of their sect. They defined experience a knowledge derived from the evidence of sense. It was either fortuitous, or acquired by design. For acquiring practical skill they recommended what they called τηρησις, or one's own observation, and the reading of histories or cases faithfully related by others. Hence they thought that we might be enabled to know a disease by its resemblance to others; and, when new diseases occurred, to conclude what was proper to be done from the symptoms they had in common with others that were before known. They asserted, that observation ought principally to be employed in two different ways; first, in discovering what things are salutary, and what are of an indifferent nature; and, secondly, what particular disease is produced by a certain concurrence of symptoms; for they did not call every symptom a disease, but only such a combination of them as from long experience they found to accompany each other, and produced such disorders as began and terminated in the same manner.

On the other hand, the dogmatist affirmed, that there was a necessity for knowing the latent as well as the evident causes of diseases, and that the physician ought to understand the natural actions and functions of the human body, which necessarily presupposes a knowledge of the internal parts. By secret or latent causes they meant such as related to the elements or principles of which our bodies are composed, and which are the origin of a good or bad state of health. They asserted that it was impossible to know how to cure a disease without knowing the cause whence it proceeded; because undoubtedly it behoved diseases to vary prodigiously in themselves according to the different causes by which they were produced.

35 Asclepiades.

The next remarkable person in the history of physic is Asclepiades, who flourished in the century immediately preceding the birth of Christ. He introduced the philosophy of Democritus and Epicurus into medicine, and ridiculed the doctrines of Hippocrates. He asserted, that matter considered in itself was of an unchangeable nature; and that all perceptible bodies were composed of a number of smaller ones, between which there were interspersed an infinity of small spaces totally void of all matter. He thought that the soul itself was composed of these small bodies. He laughed at the principle called *Nature* by Hippocrates, and also at the imaginary faculties said by him to be subservient to her; and still more at what he called *Attraction.* This last principle Asclepiades denied in every instance, even in that of the loadstone and steel, imagining that this phenomenon proceeded from a concourse of corpuscles, and a particular disposition or modification of their pores. He also maintained, that nothing happened or was produced without some cause; and that what was called *nature* was in reality no more than *matter* and *motion.* From this last principle he inferred that Hippocrates knew not what he said when he spoke of Nature as an intelligent being, and ascribed qualities of different kinds to her. For the same reason he ridiculed the doctrine of Hippocrates with regard to crises; and asserted that the termination of diseases might be as well accounted for from mere matter and motion. He maintained, that we were deceived if we imagined that nature always did good; since it was evident that she often did a great deal of harm. As for the days particularly fixed upon by Hippocrates for crises, or those on which we usually observe a change either for the better or the worse, Asclepiades denied that such alterations happened on those days rather than on others. Nay, he asserted that the crisis did not happen at any time of its own accord, or by the particular determination of nature for the cure of the disorder, but that it depended rather on the address and dexterity of the physician; that we ought never to wait till a distemper terminates of its own accord, but that the physician by his care and medicines must hasten on and advance the cure.—According to him, Hippocrates and other ancient physicians attended their patients rather with a view to observe in what manner they died than in order to cure them; and thus under pretence that Nature ought to do all herself, without any assistance.

According to Asclepiades, the particular assemblage of the various corpuscles above mentioned, and represented as of different figures, is the reason why there are several pores or interstices within the common mass, formed by these corpuscles; and why these pores are of a different size. This being taken for granted, as these pores are in all the bodies we observe, it must of course follow that the human body has some peculiar to itself, which, as well as those of all other bodies, contain certain minute bodies, which pass and repass by those pores that communicate with each other; and as these pores or interstices are larger or smaller, so the corpuscles which pass through them differ proportionally as to largeness and minuteness. The blood consists of the largest of these corpuscles, and the spirits, or the heat, of the smallest.

From these principles he infers, that as long as the corpuscles are freely received by the pores, the body remains in its natural state, and, on the contrary, it begins to recede from that state, when the corpuscles find any obstacle to their passage. Health therefore depends on the just proportion between the pores and the corpuscles they are destined to receive and transmit; as diseases, on the contrary, proceed from a disproportion between these pores and the corpuscles. The most usual obstacle on this occasion proceeds from the corpuscles embracing each other, and being retained in some of their ordinary passages, whether these corpus-
cles

cles arrive in too large a number, are of irregular figures, move too fast or too slow, &c.

Among the diseases produced by the corpuscles stopping of their own accord, Asclepiades reckoned phrensies, lethargies, pleurisies, and burning fevers. Pains, in particular, are classed among the accidents which derive their origin from a stagnation of the largest of all the corpuscles of which the blood consists. Among the disorders produced by the bad state and disposition of the pores, he placed deliquiums, languors, extenuations, leanness, and dropsies. These last disorders he thought proceeded from the pores being too much relaxed and opened: the dropsy in particular, he thinks, proceeds from the flesh being perforated with various small holes, which convert the nourishment received into them into water. Hunger, and especially that species of it called *fames canina*, proceeds from an opening of the large pores of the stomach and belly; and thirst from an opening of their small ones. Upon the same principles he accounted for intermittent fevers. According to him, quotidian fevers are caused by a retention of the largest corpuscles, those of the tertian kind by a retention of corpuscles somewhat smaller, and quartan fevers are produced by a retention of the smallest corpuscles of all.

The practice of Asclepiades was suited to remove these imaginary causes of disorders. He composed a book concerning common remedies, which he principally reduced to three, viz. gestation, friction, and the use of wine. By various exercises he proposed to render the pores more open, and to make the juices and small bodies, which cause diseases by their retention, pass more freely; and while the former physicians had not recourse to gestation till towards the end of long continued disorders, and when the patients, though entirely free from fever, were yet too weak to take sufficient exercise by walking, Asclepiades used gestation from the very beginning of the most burning fevers. He laid it down as a maxim, that one fever was to be cured by another; that the strength of the patient was to be exhausted by making him watch and endure thirst to such a degree, that, for the two first days of the disorder, he would not allow them to cool their mouths with a drop of water. Celsus also observes, that though Asclepiades treated his patients like a butcher during the first days of the disorder, he indulged them so far afterwards as even to give directions for making their beds in the softest manner. On several occasions Asclepiades used frictions to open the pores. The dropsy was one of the distempers in which this remedy was used; but the most singular attempt was, by this means, to lull phrenetic patients asleep. But though he enjoined exercise so much to the sick, he denied it to those in health; a conduct not a little surprising and extraordinary. He allowed wine freely to patients in fevers, provided the violence of the distemper was somewhat abated. Nor did he forbid it to those who were afflicted with a phrensy: nay, he ordered them to drink it till they were intoxicated, pretending by that means to make them sleep; because he said, wine had a narcotic quality and procured sleep, which he thought absolutely necessary for those who laboured under that disorder. To lethargic patients he used it on purpose to excite them, and rouse their senses: he also made them smell strong-scented substances, such as vinegar, castor, and rue, in order to make them sneeze; and applied to their heads cataplasms of mustard made up with vinegar.

Asclepiades, &c.

Besides these remedies, Asclepiades enjoined his patients abstinence to an extreme degree. For the first three days, according to Celsus, he allowed them no aliment whatever, but on the fourth began to give them victuals. According to Cælius Aurelianus, however, he began to nourish his patients as soon as the accession of the disease was diminished, not waiting til an entire remission; giving to some aliments on the first, and some on the second, to some on the third, and so on to the seventh day. It seems almost incredible to us, that people should be able to fast till this last-mentioned term; but Celsus assures us, that abstinence till the seventh day was enjoined even by the predecessors of Asclepiades.

The next great revolution which happened in the medicinal art, was brought about by Themison, the disciple of Asclepiades, who lived not long before the time of Celsus, during the end of the reign of Augustus, or beginning of that of Tiberius. The sect founded by him was called *methodic*, because he endeavoured to find a method of rendering medicine more easy than formerly.

36 Methodic sect.

37 Themison.

He maintained, that a knowledge of the causes of diseases was not necessary, provided we have a due regard to what diseases have in common and analogous to one another. In consequence of this principle, he divided all diseases into two, or at most three, kinds. The first included diseases arising from stricture; the second, those arising from relaxation; and the third, those of a mixed nature, or such as partook both of stricture and relaxation.

Themison also asserted, that diseases are sometimes acute, and sometimes chronical; that for a certain time they increase; that at a certain time they are at their height; and that at last they were observed to diminish. Acute diseases, therefore, according to him, must be treated in one way, and chronical diseases in another; one method must be followed with such as are in their augmentation, another with such as are at their height, and a third with such as are in their declension. He asserted that the whole of medicine consisted in the observation of that small number of rules which are founded upon things altogether evident. He said, that all disorders, whatever their nature was, if included under any of the kinds above mentioned, ought to be treated precisely in the same way, in whatever country and with whatever symptoms they happen to arise. Upon these principles, he defined medicine to be a method of conducting to the knowledge of what diseases have in common with each other.

Themison was old when he laid the foundation of the methodic sect; and it was only brought to perfection by Thessalus, who lived under the emperor Nero. Galen and Pliny accuse this physician of intolerable insolence and vanity, and report that he gave himself the air of despising all other physicians; and so intolerable was his vanity, that he assumed the title of *the conqueror of physicians*, which he caused to be put upon his tomb in the Appian way. Never was mountebank (says Pliny) attended by a greater number of spectators

38 Thessalus.

Thessalus, &c. spectators than Thessalus had generally about him; and this circumstance is the less to be wondered at, if we consider that he promised to teach the whole art of medicine in less than six months. In reality, the art might be learned much sooner if it comprehended no more than what the methodics thought necessary; for they cut off the explanation of the causes of diseases followed by the dogmatics; and substituted in the room of the laborious observations of the empiries, indications drawn from the analogy of diseases, and the mutual resemblance they bear to each other. The most skilful of all the methodic sect, and he who put

39 Soranus. the last hand to it, was Soranus. He lived under the emperors Trajan and Adrian, and was a native of Ephesus.

40 Celsus. One of the most celebrated medical writers of antiquity was Celsus, whom we have already had occasion to mention. Most writers agree that he lived in the time of Tiberius, but his country is uncertain. It is even disputed whether or not he was a professed physician. Certain it is, however, that his books on medicine are the most valuable of all the ancients next to those of Hippocrates. From the latter, indeed, he has taken so much, as to acquire the name of the *Latin Hippocrates;* but he has not attached himself to him so closely as to reject the assistance of other authors. In many particulars he has preferred Asclepiades. With him he laughs at the critical days of Hippocrates, and ascribes the invention of them to a foolish and superstitious attachment to the Pythagorean doctrine of numbers. He also rejected the doctrine of Hippocrates with regard to venesection, of which he made a much more general use; but did not take away so much blood at a time, thinking it much better to repeat the operation than weaken the patient by too great an evacuation at once. He used cupping also much more frequently, and differed from him with regard to purgatives. In the beginning of disorders, he said, the patients ought to endure hunger and thirst: but afterwards they were to be nourished with good aliments; of which, however, they were not to take too much, nor fill themselves suddenly, after having fasted long. He does not specify how long the patient ought to practise abstinence; but affirms, that in this particular it is necessary to have a regard to the disease, the patient, the season, the climate, and other circumstances of a like nature. The signs drawn from the pulse he looked upon to be very precarious and uncertain. "Some (says he) lay great stress upon the beating of the veins or the arteries; which is a deceitful circumstance, since that beating is slow or quick, and varies very much, according to the age, sex, and constitution of the patient. It even sometimes happens that the pulse is weak and languid when the stomach is disordered, or in the beginning of a fever. On the contrary, the pulse is often high, and in a violent commotion, when one has been exposed to the sun, or comes out of a bath, or from using exercise; or when one is under the influence of anger, fear, or any other passion. Besides, the pulse is easily changed by the arrival of the physician, in consequence of the patient's anxiety to know what judgment he will pass upon his case. To prevent this, the physician must not feel the patient's pulse on his first arrival: he must first sit down by him, assume a cheerful air, inform himself of his condition; and if he is under any dread, endeavour to remove it by encouraging discourse; after which he may examine the beating of the artery. This, nevertheless, does not hinder us from concluding, that if the sight of the physician alone can produce so remarkable a change in the pulse, a thousand other causes may produce the same effect." But although Celsus thought for himself, and in not a few particulars differed from his predecessors, yet in his writings, which are not only still preserved, but have gone through almost innumerable editions, we have a compendious view of the practice of almost all his predecessors; and he treats of the healing art in all its branches, whether performed *manu, victu, vel medicamentis.* His writings, therefore, will naturally be consulted by every one who wishes either to become acquainted with the practice of the ancients prior to the fall of the Roman empire, or to read medical Latin in its greatest purity.

About the 131st year after Christ, in the reign of the emperor Adrian, lived the celebrated Galen, a native of Pergamus, whose name makes such a conspicuous figure in the history of physic. At this time the dogmatic, empiric, methodic, and other sects, had each their abettors. The methodics were held in great esteem, and looked upon to be superior to the dogmatics, who were strangely divided among themselves, some of them following Hippocrates, others Erasistratus, and others Asclepiades. The empirics made the least considerable figure of any. Galen undertook the reformation of medicine, and restored dogmatism. He seems to have been of that sect which was called *eclectic,* from their choosing out of different authors what they esteemed good in them, without being particularly attached to any one more than the rest. This declaration he indeed sets out with; but, notwithstanding this, he follows Hippocrates much more than any other, or rather follows nobody else but him. Though before his time several physicians had commented on the works of Hippocrates, yet Galen pretends that none of them had understood his meaning. His first attempt, therefore, was to explain the works of Hippocrates; with which view he wrote a great deal, and after this set about composing a system of his own. In one of his books entitled, "Of the establishment of medicine," he defines the art to be one which teaches to preserve health and cure diseases. In another book, however, he proposes the following definition: "Medicine (says he) is a science which teaches what is sound, and what is not so; and what is of an indifferent nature, or holds a medium between what is sound and what is the reverse." He affirmed, that there are three things which constitute the object of medicine, and which the physician ought to consider as sound, as not sound, or of a neutral and indifferent nature. These are the body itself, the signs, and the causes. He esteems the human body sound, when it is in a good state or habit with regard to the simple parts of which it is composed, and when besides there is a just proportion between the organs formed of these simple parts. On the contrary, the body is reckoned to be unsound, when it recedes from this state, and the just proportion above mentioned. It is in a state of neutrality or indifference, when it is in a medium between soundness and its opposite state. The salutary signs

Celsus, 41 Galen.

signs are such as indicate present health, and prognosticate that the man may remain in that state for some time to come. The insalubrious signs, on the contrary, indicate a present disorder, or lay a foundation for suspecting the approach of one. The neutral signs, or such as are of an indifferent nature, denote neither health nor indisposition, either for the present, or for the time to come. In like manner he speaks of causes salutary, unsalutary, and indifferent.

These three dispositions of the human body, that is, soundness, its reverse, and a neutral state, comprehend all the differences between health and disorder or indisposition: and each of these three states or dispositions has a certain extent peculiar to itself. A seund habit of body, according to the definition of it already given, is very rare, and perhaps never to be met with; but this does not hinder us to suppose such a model for regulating our judgment with respect to different constitutions. On this principle Galen establishes eight other principal constitutions, all of which differ more or less from the perfect model above mentioned. The four first are such as have one of the four qualities of hot, cold, moist, or dry, prevailing in too great a degree; and accordingly receive their denomination from that quality which prevails over the rest. The four other species of constitutions receive their denominations from a combination of the above mentioned; so that, according to his definition, there may be a hot and dry, a hot and moist, a cold and moist, and a cold and dry, constitution. Besides these differences, there are certain others which result from occult and latent causes, and which, by Galen, are said to arise from an *idiosyncrasy* of constitution. It is owing to this idiosyncrasy that some have an aversion to one kind of aliment and some to another; that some cannot endure particular smells, &c. But though these eight last-mentioned constitutions fall short of the perfection of the first, it does not thence follow, that those to whom they belong are to be classed among the valetudinary and diseased. A disease only begins when the deviation becomes so great as to hinder the due action of some parts.

Galen describes at great length the signs of a good or bad constitution, as well as those of what he calls a *neutral habit*. These signs are drawn from the original qualities of cold, hot, moist, and dry, and from their just proportion or disproportion with respect to the bulk, figure, and situation, of the organical parts. With Hippocrates he establishes three principles of an animal body; the parts, the humours, and the spirits. By the parts he properly meant no more than the solid parts; and these he divided into similar and organical. Like Hippocrates, he also acknowledged four humours; the blood, the phlegm, the yellow bile and black bile. He established three different kinds of spirits; the natural, the vital, and the animal. The first of these are, according to him, nothing else but a subtle vapour arising from the blood, which draws its origin from the liver, the organ or instrument of sanguification. After these spirits are conveyed to the heart, they, in conjunction with the air we draw into the lungs, become the matter of the second species, that is, of the vital spirits, which are again changed into those of the animal kind in the brain. He supposed that these three species of spirits served as instruments to three kinds of faculties, which reside in the respective parts where these faculties are formed. The natural faculty is the first of these, which he placed in the liver, and imagined to preside over the nutrition, growth, and generation, of the animal. The vital faculty he lodged in the heart, and supposed that by means of the arteries it communicated warmth and life to all the body. The animal faculty, the noblest of all the three, and with which the reasoning or governing faculty was joined, according to him, has its seat in the brain; and, by means of the nerves, distributes a power of motion and sensation to all the parts, and presides over all the other faculties. The original source or principle of motion in all these faculties, Galen, as well as Hippocrates, defines to be *Nature*.

Upon these principles Galen defined a disease to be "such a preternatural disposition or affection of the parts of the body, as primarily, and of itself, hinders their natural and proper action." He established three principal kinds of diseases: the first relates to the similar parts; the second, to the organical; and the third is common to both these parts. The first kind of diseases consists in the intemperature of the similar parts; and this is divided into an intemperature *without matter*, and an intemperature *with matter*. The first discovers itself when a part has more or less heat or cold than it ought to have, without that change of quality in the part being supported and maintained by any matter. Thus, for instance, a person's head may be overheated and indisposed by being exposed to the heat of the sun, without that heat being maintained by the continuance or congestion of any hot humour in the part. The second sort of intemperature is when any part is not only rendered hot or cold, but also filled with a hot or cold humour, which are the causes of the heat or cold felt in the part. Galen also acknowledged a simple intemperature: that is, when one of the original qualities, such as heat or cold, exceeds the natural standard alone and separately; and a compound intemperature, when two qualities are joined together, such as heat and dryness, or coldness and humidity. He also established an equal and unequal temperature. The former is that which is equally in all the body, or in any particular part of it, and which creates no pain, because it is become habitual, such as dryness in the hectic constitution. The latter is distinguished from the former, in that it does not equally subsist in the whole of the body, or in the whole of a part. Of this kind of intemperature we have examples in certain fevers, where heat and cold, equally, and almost at the same time, attack the same part; or in other fevers which render the surface of the body cold as ice, while the internal parts burn with heat; or, lastly, in cases where the stomach is cold and the liver hot.

The second kind of disorders, relating to the organical parts, results from irregularities of these parts, with respect to the number, bulk, figure, situation, &c. as when one has six fingers, or only four; when one has any part larger or smaller than it ought to be, &c. The third kind, which is common both to the similar and the organical parts, is a solution of continuity, which happens when any similar or compound part is cut, bruised, or corroded.

Like

Galen.

Like Hippocrates, Galen distinguished diseases into acute and chronical; and, with respect to their nature and genius, into benign and malignant; also into epidemic, endemic, and sporadic.

After having distinguished the kinds of diseases, Galen comes to explain their causes; which he divides into external and internal. The external causes of diseases, according to him, are six things, which contribute to the preservation of health when they are well disposed and properly used, but produce a contrary effect when they are imprudently used or ill disposed. These six things are, the air, aliments and drink, motion and rest, sleeping and watching, retention and excretion, and lastly the passions. All these are called the *procatarctic* or *beginning* causes, because they put in motion the internal causes; which are of two kinds, the *antecedent* and the *conjunct*. The former is discovered only by reasoning; and consists for the most part in a peccancy of the humours, either by plenitude or cacochymy, i. e. a bad state of them. When the humours are in too large a quantity, it is called a *plethora;* but we must observe, that this word equally denotes too large a quantity of all the humours together, or a redundance of one particular humour which prevails over the rest. According to these principles, there may be a sanguine, a bilious, a pituitous, or a melancholy plenitude: but there is this difference between the sanguine and the three other plenitudes, that the blood, which is the matter of the former, may far surpass the rest: whereas, if any of the three last-mentioned ones do so, the case is no longer called *plenitude*, but *cacochymia;* because these humours, abounding more than they ought, corrupt the blood. The causes he also divides into such as are manifest and evident, and such as are latent and obscure. The first are such as spontaneously come under the cognizance of our senses when they act or produce their effects: the second are not of themselves perceptible, but may be discovered by reasoning: the third sort, i. e. such as he calls *occult* or *concealed*, cannot be discovered at all. Among this last he places the cause of the hydrophobia.

He next proceeds to consider the symptoms of diseases. A symptom he defines to be "a preternatural affection depending upon a disease, or which follows it as a shadow does a body." He acknowledged three kinds of symptoms: the first and most considerable of these consisted in the action of the parts being injured or hindered; the second in a change of the quality of the parts, their actions in the mean time remaining entire: the third related to defects in point of excretion and retention.

After having treated of symptoms, Galen treats of the *signs* of diseases. These are divided into *diagnostic* and *prognostic*. The first are so called because they enable us to know diseases, and distinguish them from each other. They are of two sorts, *pathognomonic* or *adjunct*. The first are peculiar to every disease, make known its precise species, and always accompany it, so that they begin and end with it. The second are common to several diseases, and only serve to point out the difference between diseases of the same species. In a pleurisy, for instance, the pathognomonic signs are a cough, a difficulty of breathing, a pain of the side, and a continued fever; the adjunct signs are the various sorts of matter expectorated, which is sometimes bloody, sometimes bilious, &c.— The diagnostic signs were drawn from the defective or disordered disposition of the parts, or from the diseases themselves; secondly, from the causes of diseases; thirdly, from their symptoms; and lastly, from the particular dispositions of each body, from things which prove prejudicial and those that do service, and from epidemical diseases.—The prognostic signs he gathered from the species, virulence, and peculiar genius of the disease: but as we have already spoken so largely concerning the prognostics of Hippocrates, it is superfluous to be particular on those of Galen.— His method of cure differed little from that of Hippocrates: but from the specimen already given of Galen's method of teaching the medical art, it is evident that his system was little else than a collection of speculations, distinctions, and reasonings; whereas that of Hippocrates was founded immediately upon facts, which he had either observed himself, or had learned from the observation of others.

Oribasi &c.

The system of Galen, however, notwithstanding its defects and absurdities, remained almost uncontradicted for a very long period. Indeed it may be considered as having been the prevailing system till the inundation of the Goths and Vandals put an almost entire stop to the cultivation of letters in Europe. But during the general prevalence of the system of Galen, there appeared some writers to whom medicine was indebted for improvements, at least in certain particulars. Among the most distinguished of these we may mention Oribasius, Ætius, Alexander, and Paulus.

4 Oriba

Oribasius flourished about the year 360, and was physician to the emperor Julian. He speaks very fully of the effects of bleeding by way of scarification, a thing little taken notice of by former writers; from his own experience he assures us that he had found it successful in a suppression of the menses, defluxions of the eyes, headach, and straitness of breathing even when the person was extremely old. He tells his own case particularly, when the plague raged in Asia and he himself was taken ill. On the second day he scarified his leg, and took away two pounds of blood; by which means he entirely recovered, as did several others who used it. In this author also we find the first description of a surprising and terrible distemper, which he termed λυκανθρωπια, a species of melancholy and madness, which he describes thus. "The persons affected get out of their houses in the night-time, and in every thing imitate wolves, and wander among the sepulchres of the dead till day-break. You may know them by these symptoms: Their looks are pale; their eyes heavy, hollow, dry, without the least moisture of a tear; their tongue exceedingly parched and dry, no spittle in their mouth, extreme thirst; their legs, from the falls and the bruises they receive, full of incurable sores and ulcers."

4 Ætiu

Ætius lived very near the end of the fifth, or in the beginning of the sixth century. Many passages in his writings serve to shew us how much the actual and potential cautery were used by the physicians of that age. In a palsy, he says, that he should not at all hesitate to make an eschar either way, and this in several places; one in the nape, where the spinal marrow takes its rise, two on each side of it; three or four

Alexander. four on the top of the head, one just in the middle, and three others round it. He adds, that in this case, if the ulcers continue running a considerable time, he should not doubt of a perfect recovery. He is still more particular when he comes to order this application for an inveterate asthma, after all other remedies have been tried in vain. One, he says, should be made on each side near the middle of the joining of the clavicle, taking care not to touch the wind-pipe: two other little ones are then to be made near the carotids under the chin, one on each side, so that the caustic may penetrate no further than the skin: two others under the breasts, between the third and fourth ribs; and again, two more backwards towards the fifth and sixth ribs. Besides these there ought to be one in the middle of the thorax, near the beginning of the xiphoid cartilage, over the orifice of the stomach; one on each side between the eighth and ninth ribs; and three others in the back, one in the middle, and the two others just below it, on each side of the vertebræ. Those below the neck ought to be pretty large, not very superficial, not very deep: and all these ulcers should be kept open for a very long time.

Ætius takes notice of the worms bred in different parts of the body, called *dracunculi*, which were unknown to Galen. He seems also to be the first Greek writer among the Christians, who gives us any specimen of medicinal spells and charms; such as that of a finger of St Blasius for removing a bone which sticks in the throat, and another in relation to a fistula. He gives a remedy for the gout, which he calls the *grand drier;* the patient is to use it for a whole year, and observe the following diet each month. "In September, he must eat and drink milk: In October he must eat garlic; in November, abstain from bathing; in December, he must eat no cabbage; in January, he is to take a glass of pure wine in the morning; in February, to eat no beef; in March, to mix sweet things both in eatables and drinkables; in April, not to eat horse-radish, nor in Mayt he fish called *polypus;* in June, he is to drink cold water in a morning; in July, to avoid venery; and lastly, in August, to eat no mallows." This may sufficiently show the quackery of those times, and how superstition was beginning to mix itself with the art.

44 Alexander. Alexander, who flourished in the reign of Justinian, is a more original author than either of the two former. He confines himself directly to the describing the signs of diseases, and the methods of cure, without meddling with anatomy, the materia medica, or surgery, as all the rest did. He employs a whole book in treating of the gout. One method he takes of relieving this disease is by purging; and in most of the purges he recommends hermodactyls, of which he has a great opinion. In a causus, or burning fever, where the bile is predominant, the matter fit for evacuation, and the fever not violent, he prefers purging to bleeding, and says that he has often ordered purging in acute fevers with surprising success. In the causus also, if a syncope happens from crude and redundant humours, he recommends bleeding. In a syncope succeeding the suppression of any usual evacuation, he recommends bleeding, with frictions. The diagnostics upon which he founds this practice are the following: viz. a face paler and more swelled than usual, a bloated habit of body, with a small sluggish pulse, having long intervals between the strokes. In tertian, and much more in quartan fevers, he recommends vomits above all other remedies, and affirms that by this remedy alone he has cured the most inveterate quartans. On the bulimus, or canine appetite, he makes a new observation, viz. that it is sometimes caused by worms. He mentions the case of a woman who laboured under this ravenous appetite, and had a perpetual gnawing at her stomach and pain in her head: after taking *hiera* she voided a worm above a dozen of cubits long, and was entirely cured of her complaints.—He is also the first author who takes notice of *rhubarb;* which he recommends in a weakness of the liver and in dysentery.—Alexander is recommended by Dr Freind as one of the best practical writers among the ancients, and well worthy the perusal of any modern. Arabian Physicians.

45 Paulus. Paulus was born in the island Ægina, and lived in the 7th century. He transcribes a great deal from Alexander and other physicians. His descriptions are short and accurate. He treats particularly of women's disorders; and seems to be the first instance upon record of a professed *man-midwife*, for so he was called by the Arabians: and accordingly he begins his book with the disorders incident to pregnant women. He treats also very fully of surgery, and gives some directions, according to Dr Freind, not to be found in the more ancient writers.

46 Arabian physicians. After the downfal of the Roman empire, and when the inundation of Goths and Vandals had almost completely exterminated literature of every kind in Europe, medicine, though a practical art, shared the same fate with more abstract sciences. Learning in general, banished from the seat of arms, took refuge among the eastern nations, where the arts of peace still continued to be cultivated. To the Arabian physicians, as they have been called, we are indebted both for the preservation of medical science, as it subsisted among the Greeks and Romans, and likewise for the description of some new diseases, particularly the small-pox. Among the most eminent of the Arabians, we may mention Rhases, Avicenna, Albucasis, and Avenzoar. But of their writings it would be tedious, and is unnecessary, to give any particular account.—They were for the most part, indeed, only copiers of the Greeks. We are, however, indebted to them for some improvements. They were the first who introduced chemical remedies, though of these they used but few, nor did they make any considerable progress in the chemical art. Anatomy was not in the least improved by them, nor did surgery receive any advancement till the time of Albucasis, who lived probably in the 12th century. They added a great deal to botany and the materia medica, by the introduction of new drugs, of the aromatic kind especially, from the east, many of which are of considerable use. They also found out the way of making sugar; and by help of that, syrups; which two new materials are of great use in mixing up compound medicines. 47 Rhases.

With regard to their practice, in some few particulars they deviated from the Greeks. Their purging medicines were much milder than those formerly in use; and even when they did prescribe the old ones, they gave them in a much less dose than the Greek and Roman physicians. The same reflection may be made concerning

Arabian Physicians.

concerning their manner of bleeding, which was never to that excessive degree practised by the Greeks. They deviated from Hippocrates, however, in one very trivial circumstance, which produced a violent controversy. The question was, Whether blood in a pleurisy ought to be drawn from the arm of the affected side or the opposite? Hippocrates had directed it to be drawn from the arm of the affected side; but the Arabians, following some other ancient physicians, ordered it to be drawn from the opposite one. Such was the ignorance of those ages, that the university of Salamanca in Spain made a decree, that no one should dare to let blood but in the contrary arm; and endeavoured to procure an edict from the emperor Charles V. to second it; alleging that the other method was of no less pernicious consequence to medicine, than Luther's heresy had been to religion.

In consequence of the general decay of learning in the western parts of the world, the Greek writers were entirely neglected, because nobody could read the language; and the Arabians, though principally copiers from them, enjoyed all the reputation that was due to the others. The Arabian physic was introduced into Europe very early, with the most extravagant applause: and not only this, but other branches of their learning, came into repute in the west; insomuch that in the 11th century, the studies of natural philosophy and the liberal arts were called *the studies of the Saracens*. This was owing partly to the crusades undertaken against them by the European princes; and partly to the settlement of the Moors in Spain, and the intercourse they and other Arabians had with the

48 College of Salernum.

Italians. For, long before the time of the crusades, probably in the middle of the 7th century, there were Hebrew, Arabic, and Latin professors of physic settled at Salernum: which place soon grew into such credit, that Charles the Great thought proper to found a college there in the year 802; the only one at that

49 Constantine.

time in Europe. Constantine the African flourished there towards the latter end of the 11th century. He was a native of Carthage; but travelled into the east, and spent 30 years in Babylon and Bagdad, by which means he became master of the oriental languages and learning. He returned to Carthage; but being informed of an attempt against his life, made his escape into Apulia, where he was recommended to Robert Guiscard, created in 1060 duke of that country, who made him his secretary. He was reputed to be very well versed in the Greek, as well as in the eastern tongues; and seems to have been the first who introduced either the Greek or Arabian physic into Italy. His works, however, contain nothing that is new, or material; though he was then accounted a very learned man.

50 State of medicine in the 15th and 16th centuries.

From this time to the end of the 15th and beginning of the 16th century, the history of physic furnishes us with no interesting particulars. This period, however, 'is famous for the introduction of chemistry into medicine, and the description of three new distempers, the sweating sickness, the venereal disease, and the scurvy. The sweating sickness began in 1485

51 Sweating sickness in England.

in the army of Henry VII. upon his landing at Milford-haven, and spread itself at London, from the 21st of September to the end of October. It returned there five times, and always in summer; first in 1495, then in 1506, afterwards in 1517, when it was so violent that it killed many in the space of three hours, so that numbers of the nobility died, and of the commonalty in several towns often the one-half perished. It appeared the fourth time in 1528, and then proved mortal in six hours; many of the courtiers died of it, and Henry VIII. himself was in danger. In 1529, and only then, it infested the Netherlands and Germany, in which last country it did much mischief. The last return of it was in 1551, and in Westminster it carried off 120 in a day. Dr Caius describes it as a pestilent contagious fever, of the duration of one natural day; the sweat he reckoned to be only a natural symptom, or crisis of the distemper. It first affected some particular part, attended with inward heat and burning, unquenchable thirst, restlessness, sickness at stomach, but seldom vomiting, headach, delirium, then faintness, and excessive drowsiness. The pulse was quick and vehement, and the breath short and laborious.—Children, poor and old people, were rarely subject to it. Of others, scarce any escaped the attack, and most of them died. Even by travelling into France or Flanders they did not escape; and what is still more strange, the Scots were said not to be affected; abroad the English only were seized, and foreigners in England were free. At first the physicians were much puzzled how to treat this disease. The only cure they ever found, however, was to carry on the sweat for a long time; for, if stopped, it was dangerous or fatal. The way, therefore, was for the patient to lie still, and not expose himself to cold. If nature was not strong enough to force out the sweat, it was necessary to assist her by art, with clothes, wine, &c. The violence of the distemper was over in 15 hours; but there was no security for the patient till 24 were passed. In some strong constitutions there was a necessity to repeat the sweating, even to 12 times. The removing out of bed was attended with great danger; some who had not sweated enough fell into very bad fevers.—No flesh-meat was to be allowed in all the time of the distemper; nor drink for the first five hours. In the seventh, the distemper increased; in the ninth the delirium came on, and sleep was by all means to be avoided. However terrible this distemper appeared at first, it seldom proved obstinate, if treated in the above-mentioned manner.

Para[...]

In the beginning of the 16th century, the famous chemist Paracelsus introduced a new system into medicine, founded on the principles of chemistry. The Galenical system had prevailed till his time; but the practice had greatly degenerated, and was become quite trifling and frivolous. The physicians in general rejected the use of opium, mercury, and other efficacious remedies. Paracelsus, who made use of these, had therefore greatly the advantage over them; and now all things relating to medicine were explained on imaginary chemical principles. It will easily be conceived that a practice founded in this manner could be no other than the most dangerous quackery. At this time, however, it was necessary; for now a new disease overran the world, and threatened greater destruction than almost all the old ones put together, both by the violence of its symptoms, and its baffling the most powerful remedies at that time known.—This was the venereal disease, which is supposed to have been imported derns.

imported from the West Indies by the companions of Christopher Columbus. Its first remarkable appearance was at the siege of Naples in 1494, from whence it was soon after propagated through Europe, Asia, and Africa. The symptoms with which it made the attack at that time were exceedingly violent, much more so than they are at present; and consequently were utterly unconquerable by the Galenists. The quacks and chemists, who boldly ventured on mercury, though they no doubt destroyed numbers by their excessive use of it, yet showed that a remedy for this terrible distemper was at last found out, and that a proper method of treating it might soon be fallen upon. Shortly after, the West Indian specific, guaiacum, was discovered: the materia medica was enriched with that and many other valuable medicines, both from the East and West Indies: which contributed considerably to the improvement of the practice of physic. At this period, as sea voyages of considerable duration were more frequent, the scurvy became a more common distemper, and was of course more accurately described. But probably, from supposed analogy to the contagions which at that time were new in Europe, very erroneous ideas were entertained with regard to its being of an infectious nature: And it is not impossible, that from its being attended also with ulcers, it was on some occasions confounded with syphilitic complaints.

53 [A]ppearance [of th]e ve[ner]eal dis[eas]e.

54 P[rog]ress of m[edic]ine in th[e 1]7th a[nd 1]8th ce[ntu]ries.

The revival of learning, which now took place throughout Europe, the appearance of these new distempers, and the natural fondness of mankind for novelty, contributed greatly to promote the advancement of medicine as well as other sciences. While at the same time, the introduction of the art of printing rendered the communication of new opinions as well as new practices so easy a matter, that to enumerate even the names of those who have been justly rendered eminent for medical knowledge would be a very tedious task. It was not, however, till 1628 that Dr William Harvey of London demonstrated and communicated to the public one of the most important discoveries respecting the animal economy, the circulation of the blood. This discovery, more effectually than any reasoning, overturned all the systems which had subsisted prior to that time. It may justly be reckoned the most important discovery that has hitherto been made in the healing art: for there can be no doubt that it puts the explanation of the phenomena of the animal body, both in a state of health and disease, on a more solid and rational footing than formerly. It has not, however, prevented the rise of numerous fanciful and absurd systems. These, though fashionable for a short time, and strenuously supported by blind adherents, have yet in no long period fallen into deserved contempt. And notwithstanding the abilities and industry of Stahl, Hoffman, Boerhaave, and Cullen, we may confidently venture to assert that no general system has yet been proposed which is not liable to innumerable and unsurmountable objections. Very great progress has indeed been made in explaining the philosophy of the human body, from ascertaining by decisive experiment the influence of the circulating, the nervous, and the lymphatic systems in the animal economy. But every attempt hitherto made to establish any general theory in medicine, that is, to conduct the cure of every disease on a few general principles, has equally deviated from truth with those of Hippocrates and Galen; and has equally tended to mislead those who have adopted it. Many systems of our own days, such for example as that of Brown, though adopted with enthusiasm by the young and inexperienced, have evidently been attended with the most pernicious consequences in practice. Indeed we may with confidence venture to assert, that from the very nature of the subject itself, medicine does not admit of such simplicity. No one can deny that the human body consists of a very great number of different parts, both solids and fluids. It is, however, equally certain, that each of these is from many different causes liable to deviations from the sound state. And although some slight changes may take place without what can be called a morbid affection, yet we well know, that every change taking place to a certain degree in any one part will necessarily and unavoidably produce an affection of the whole. Hence we may without hesitation venture to affirm, that every general theory which can be proposed, attempting to explain the phenomena, and conduct the cure of all diseases on a few general principles, though for some time it may have strenuous advocates, will yet in the end be found to be both ill-grounded and pernicious.

55 Di[sco]very of [cir]cu[lati]on.

Moderns.

The art of medicine has been much more usefully improved by careful attention to the history, theory, and practice of particular diseases, and by endeavouring to ascertain from cautious observation the symptoms by which they are to be distinguished, the causes by which they are induced, and the means by which they are to be prevented, alleviated, or cured. On this footing, therefore, we shall endeavour to give a brief account of at least the most important affections to which the human body is subjected, delivering what appear to us to be the best established facts and observations respecting each.

But before entering on the consideration of particular diseases, or what has commonly been styled the practice of medicine, it is necessary to give a general view of the most important functions of the animal body, and of the chief morbid affections to which they are subjected; a branch which has usually been named the *Theory* or *Institutions of Medicine*.

Theory of Medicine, or an Account of the Principal Functions of the Animal Body.

WHILE the functions of living animals, but particularly of the human species, are very numerous, the accounts given of these both in a state of health and disease are very various. Without, therefore, pretending to enumerate the contradictory opinions of different authors, we shall here present the reader with a view of this subject, Functions of the Body.

subject, chiefly extracted from the *Conspectus Medicinæ Theoreticæ* of Dr James Gregory, who has collected from other writers the opinions at present most generally adopted.

56 Division of the functions into animal, vital, and natural.

In this work, which was first published in 1780, and afterwards reprinted under an enlarged form in 1782, Dr Gregory introduces his subject by observing, that some functions of the human body relate to itself only, and others to external things. To the latter class belong those which by physicians are called the *animal functions;* to which are to be referred all our senses, as well as the power of voluntary motion, by which we become acquainted with the universe, and enjoy this earth. Among the functions which relate to the body, some have been named *vital*, such as the circulation of the blood and respiration; because, without the constant continuance of these life cannot subsist; others, intended for repairing the waste of the system, have been termed the *natural functions:* for by the constant attrition of the solids and the evaporation of the fluid parts of the body, we stand in need of nourishment to supply the waste; after which the putrid and excrementitious parts must be thrown out by the proper passages. The digestion of the food, secretion of the humours, and excretion of the putrid parts of the food, are referred to this class; which, though necessary to life, may yet be interrupted for a considerable time without danger. This division of the functions into animal, vital, and natural, is of very ancient date, and is perhaps one of the best that has yet been proposed.

57 Distinction of diseases into simple and compound.

A *disease* takes place, when the body has so far declined from a sound state, that its functions are either quite impeded, or performed with difficulty. A disease therefore may happen to any part of the body either solid or fluid, or to any one of the functions: and those may occur either singly, or several of them may be diseased at the same time; whence the distinction of diseases into *simple* and *compound*.

We have examples of the most simple kinds of diseases, in the rupture or other injury of any of the corporeal organs, by which means they become less fit for performing their offices; or, though the organs themselves should remain sound, if the solids or fluids have degenerated from a healthy state; or if, having lost their proper qualities, they nave acquired others of a different, perhaps of a noxious nature; or, lastly, if the moving powers shall become too weak or too strong, or direct their force in a way contrary to what nature requires.

58 Symptoms.

The most simple diseases are either productive of others, or of *symptoms*, by which alone they become known to us. Every thing in which a sick person is observed to differ from one in health is called a *symptom;* and the most remarkable of these symptoms, which most commonly appear, define and constitute the disease.

The causes of diseases are various; often obscure, and some times totally unknown. The most full and perfect proximate cause is that which, when present, produces a disease, when taken away removes it, and when changed, changes it.—There are also remote causes, which physicians have been accustomed to divide into the *predisponent* and *exciting* ones. The

59 Predisponent cause.

former are those which only render the body fit for a disease, or which put it into such a state that it will readily receive one. The exciting cause is that which immediately produces the disease in a body already disposed to receive it.

Causes of Disease.

60 Exciting cause.

The predisponent cause is always inherent in the body itself, though perhaps it originally came from without; thus heat or cold, a very sparing or a very luxurious diet, and many other particulars, may operate as causes of predisposition, inducing plethora, inanition, or the like. But the exciting cause may either come from within or without.

61 Proximate cause.

From the combined action of the predisponent and exciting causes comes the *proximate* cause, which neither of the two taken singly is often able to produce.—A body predisposed to disease therefore has already declined somewhat from a state of perfect health, although none of its functions are impeded in such a manner that we can truly say the person is diseased. Yet sometimes the predisponent cause, by continuing long, may arrive at such a height, that it alone, without the addition of any exciting cause, may produce a real disease.—The exciting cause also, though it should not be able immediately to bring on a disease; yet if it continues long, will by degrees destroy the strongest constitution, and render it liable to various diseases; because it either produces a predisponent cause, or is converted into it, so that the same thing may sometimes be an exciting cause, sometimes a predisponent one, or rather a cause of predisposition; of which the inclemencies of the weather, sloth, luxury, &c. are examples.

Hereditary diseases.

Diseases, however, seem to have their origin from the very constitution of the animal machine; and hence many diseases are common to every body when a proper exciting cause occurs, though some people are much more liable to certain diseases than others. Some are hereditary; for as healthy parents naturally produce healthy children, so diseased parents as naturally produce a diseased offspring. Some of these diseases appear in the earliest infancy; others occur equally at all ages; nor are there wanting some which lurk unsuspected even to the latest old age, at last breaking out with the utmost violence. Some diseases are born with us even though they have no proper foundation in our constitution, as when a fœtus receives some hurt by an injury done to the mother; while others, neither born with us nor having any foundation in the constitution, are suckled in with the nurse's milk. Many diseases accompany the different stages of life; and hence some are proper to infancy, youth, and old age. Some also are proper to each of the sexes: especially the female sex, proceeding, no doubt, from the general constitution of the body, but particularly from the state of the parts subservient to generation. Hence the diseases peculiar to virgins, to menstruating women, to women with child, to lying-in women, to nurses, and to old women. The climate itself, under which people live, produces some diseases; and every climate has a tendency to produce particular diseases, either from its excess of heat or cold, or from the mutability of the weather. An immense number of diseases also may be produced by impure air, or such as is loaded with putrid, marshy, and other noxious vapours. The same

Diseases from age and sex.

Diseases from climate.

...s of ...ses. same thing may happen likewise from corrupted aliment, whether meat or drink; though even the best and most nutritious aliment will hurt if taken in too great quantity; not to mention poisons, which are endowed with such pernicious qualities, that even when taken in a very small quantity they produce the most grievous diseases or perhaps even death itself. Lastly, from
5 ...ses ...acci- innumerable accidents and dangers to which mankind are exposed, they frequently come off with broken limbs, wounds, and contusions, sometimes quite incurable; and these misfortunes, though proceeding from an external cause at first, often terminate in internal diseases.

Hitherto we have mentioned only the dangers which come from without; but those are not less, nor fewer in number, which come from within. At every breath, man pours forth a deadly poison both to himself and others. Neither are the effluvia of the lungs alone hurtful: there flows out from every pore of the body a most subtile and poisonous matter, perhaps of a putrescent nature, which being long accumulated, and not allowed to diffuse itself through the air, infects the body with most grievous diseases; nor does it stop here, but produces a contagion which spreads devastation far and wide among mankind. From too much or too little exercise of our animal powers also no small danger ensues. By inactivity either of body or mind, the vigour of both is impaired; nor is the danger much less from too great employment. By moderate use, all the faculties of the mind, as well as all the parts of the body, are improved and strengthened; and here nature has appointed certain limits, so that exercise can neither be too much neglected, nor too much increased, with impunity. Hence those who use violent exercise, as well as those who spend their time in sloth and idleness, are equally liable to diseases; but each to diseases of a different kind: and hence also the bad effects of too great or too little employment of the mental powers.

6 ...ses ...pas- ...of the Besides the dangers arising from those actions of the body and mind which are in our own power, there are others arising from those which are quite involuntary. Thus, passions of the mind, either when carried to too great excess, or when long continued, equally destroy the health; nay, will even sometimes bring on sudden death. Sleep also, which is of the greatest service in restoring the exhausted strength of the body, proves noxious either from its too great or too little quantity. In the most healthy body, also, many things always require to be evacuated. The retention of these is hurtful, as well as too profuse an evacuation, or the excretion of those things either spontaneously or artificially which nature directs to be retained. As the solid parts sometimes become flabby, soft, almost dissolved, and unfit for their proper offices; so the fluids are sometimes inspissated, and formed even into the hardest solid masses. Hence impeded actions of the organs, vehement pain, various and grievous diseases. Lastly, some animals are to be reckoned among the causes of diseases: such, particularly, as support their life at the expence of others; and these either invade us from without, or take up their residence within the body, gnawing the bowels while the person is yet alive, not only with great danger and distress to the patient, but sometimes even producing death itself.

Man, however, is not left without defence against so many and so great dangers. The human body is possessed of a most wonderful power, by which it preserves itself from diseases, keeps off many, and, in a very short time, cures some already begun, while others are by the same means more slowly brought to a happy conclusion. This power, called the *autocrateia*, or *vis medicatrix naturæ*, is well known both to physicians and philosophers. This alone is often sufficient for curing many diseases, and is of service in all. Nay, even the best medicines operate only by exciting and properly directing this force; for no medicine will act on a dead carcase. But though physicians justly put confidence in this power, and though it generally cures diseases of a slighter nature, it is not to be thought that those of the more grievous kind are to be left to the unassisted efforts of the *vis medicatrix*. Physicians therefore have a twofold error to avoid, either despising the powers of nature too much, or putting too great confidence in them; because in many diseases these efforts are either too feeble or too violent, insomuch that sometimes they are more to be dreaded than even the disease itself. So far therefore is it from being the duty of a physician always to follow the footsteps of nature, that it is often necessary for him to take a directly contrary course, and oppose her efforts with all his might. 67 *Vis medicatrix naturæ.*

After a general view of the functions of the animal body, of the nature and causes of disease, and of the powers by which these are to be combated, Dr Gregory proceeds to treat of the solid materials of which the body is formed. He tells us, that the animal solid, when chemically examined, yields earth, oil, salt, water, phlogiston or inflammable air, and a great quantity of mephitic air. These elements are found in various proportions in the different parts of the body; and hence these parts are endowed with very different mechanical powers, from the hardest and most solid bone to the soft and almost fluid retina. Nay, it is principally in this difference of proportion between the quantities of the different elements, that the difference between the solid and fluid parts of the animal consist, the former having much more earth and less water in their composition than the latter. The cohesion, he thinks, is owing to something like a chemical attraction of the elements for one another; and its cause is neither to be sought for in the gluten, fixed air, nor earth. This attraction, however, is not so strong but that even during life the body tends to dissolution; and immediately after death putrefaction commences, provided only there be as much moisture in it as will allow an intestine motion to go on. The greater the heat, the sooner does putrefaction take place, and with the greater rapidity does it proceed; the mephitic air flies off, and together with it certain saline particles; after which, the cohesion of the body being totally destroyed, the whole falls into a putrid colluvies, of which at length all the volatile parts being dissipated, nothing but the earth is left behind. 68 Chemical analysis of the animal solids.

This analysis, he owns, is far from being perfect, and is by no means in the language of modern chemistry.

Animal Solids.

try. But no modern chemist has ever been able, by combining the chemical principles of flesh, to reproduce a compound any thing like what the flesh originally was; yet, however imperfect the analysis may be, it still has the advantage of showing in some measure the nature and causes of certain diseases, and thus leads physicians to the knowledge of proper remedies.

69 Qualities of the animal solids.

The solid parts are fitted for the purposes of life in three several ways; namely, by their cohesion, their flexibility, and their elasticity, all of which are various in the various parts of the body. Most of the functions of life consist in various motions. In some the most violent and powerful motions are required; and therefore such a degree of cohesion is necessary in these parts as will be sufficient for allowing them to perform their offices without any danger of laceration. It is therefore necessary that some of the solid parts should be more flexible than others; and it is likewise necessary that these parts, along with their flexibility, should have a power of recovering their former shape and situation, after the removal of the force by which they were altered.

These variations in flexibility, within certain limits, seldom produce any material consequence with regard to the health: though sometimes, by exceeding the proper bounds, they may bring on real and very dangerous diseases; and this either by an excess or diminution of their cohesion, flexibility, or elasticity. By augmenting the cohesion, the elasticity is also for the most part augmented, but the flexibility diminished; by diminishing the cohesion, the flexibility becomes greater, but the elasticity is diminished.

The cause of these affections, though various, may be reduced to the following heads. Either the chemical composition of the matter itself is changed; or, the composition remaining the same, the particles of the solid may be so disposed, that they shall more or less strongly attract one another. As to the composition, almost all the elements may exist in the body in an undue proportion, and thus each contribute its share to the general disorder. But of many of these things we know very little; only it is apparent, that the fluid parts, which consist chiefly of water, and the solid, which are made up of various elements, are often in very different proportions: the more water, the less is the cohesion or elasticity, but the greater the flexibility; and the reverse happens, if the solid or earthy part predominates.

70 Causes affecting the solids.

The remote causes of these different states, whether predisponent or exciting, are very various. In the first place, idiosyncrasy itself, or the innate constitution of the body, contributes very much to produce the above-mentioned effects. Some have naturally a much harder and drier temperament of the body than others; men, for instance, more than women; which can with the utmost difficulty, indeed scarce by any means whatever, admit of an alteration. The same thing takes place at different periods of life; for, from first to last, the human body becomes always drier and more rigid. Much also depends on the diet made use of, which always produces a corresponding state of the solids in proportion to its being more or less watery. Neither are there wanting strong reasons for believing, that not only the habit of the body, but even the disposition of the mind, depends very much on the diet we make use of. The good or bad concoction of the aliment also, the application of the nourishment prepared from it, and likewise the state of the air with regard to moisture and dryness, affect the temperament of the body not a little; and hence those who inhabit mountains or dry countries, are very different from the inhabitants of low marshy places. Lastly, the manner of living contributes somewhat to this effect: Exercise presses out and exhales the moisture of the body, if in too great quantity; on the contrary, sloth and laziness produce an effect directly opposite, and cause a redundancy of fluid.

But, putting the chemical composition of the solid parts out of the question altogether, they may be affected by many other causes. The condensation, for instance, or compression of the particles, whether by mechanical causes or by means of cold or heat, makes a considerable alteration in the strength and elasticity of every solid body. How much mechanical pressure contributes to this may be understood from the experiments of Sir Clifton Wintringham: and hence also are we to deduce the reason of many facts of the highest importance in the animal economy; namely, the growth, state, decrease of the body; its rigidity daily increasing; and at last the unavoidable death incident to old age from a continuance of the same causes.

Perhaps the different density of the solids is in some measure owing to Nature herself; but it seems to depend more on the powers of exercise or inactivity in changing the state of the solids, the effects of which on the body, whether good or bad, may hence be easily understood.

Heat relaxes and expands all bodies, but cold renders them more dense and hard; the effects of which on the human body are well known to most people. Though the body is found to preserve a certain degree of heat almost in every situation, yet its surface must unavoidably be affected by the temperature of the circumambient atmosphere; and we have not the least reason to doubt that every part of the body may thus feel the effects of that temperature. What a difference is there between one who, exposed to the south wind, becomes lazy and languid, scarce able to drag along his limbs; and one who feels the force of the cold north wind, which renders the whole body alert, strong, and fit for action?

That these various causes, each of which is capable of affecting the constitution of the body when taken singly, will produce much greater effects when combined, is sufficiently evident. The experiments of Bryan Robinson, the effects of the warm bath, and indeed daily experience, show it fully.

It is not yet certainly known what is the ultimate structure of the minutest parts of the animal-solid; whether it consists of straight fibres or threads, whose length is very considerable in proportion to their breadth, variously interwoven with one another, as Boerhaave supposes; or of spiral ones, admirably convoluted and interwoven with one another, as some microscopical experiments seem to show; or whether the cellular texture be formed of fibres or *laminæ*, and from thence the greatest part of the body, as the celebrated Haller hath endeavoured to prove.

The

Animal Solids.

Cellular texture.

The cellular texture is observed throughout the whole body: it surrounds and connects the fibres themselves, which are sufficiently apparent in many of the organs; and slightly joins the different parts which ought to have any kind of motion upon the neighbouring ones. By a condensation of this substance also, the strongest, and what seem the thinnest, membranes are formed; the most simple of which being accurately examined, discover the cellular structure. This cellular substance sometimes increases to a surprising degree, and all parts formed of it, membranes, vessels, &c. especially by a gentle distension; for a sudden and violent distension either breaks it altogether, or renders it thinner. Sometimes also it grows between neighbouring parts, and joins those which nature has left free. Preternatural concretions of this kind are often observed after an inflammation of the lungs or of the abdominal viscera; and these new membranes are found to be truly cellular. This substance, when cut, or by any other means divided, grows together of its own accord; but if, by reason of very great inflammation and suppuration, a large portion of the cellular texture has been destroyed, it is never again completely renewed, and an ugly scar is left. It is even said, that this substance, in certain cases, is capable of joining the parts either of the same body with one another, or of a foreign body with them; and upon this, if on any foundation, rests the art of Taliacotius and that of transplanting teeth, lately so much talked of.

The cellular texture is in some places merely a kind of net-work, in others filled with fat. Wherever too great bulk or compression would have been inconvenient or dangerous, as in the head, lungs, eyes, eyebrows, penis, scrotum, &c. there it collects no fat, but is lax, and purely reticulated; but between the muscles of the body and limbs below the skin, in the abdomen, especially in the omentum and about the kidneys, very much fat is secreted and collected.

Animal fat.

The fat is principally a pure animal oil, not very different from the expressed and mild vegetable ones; during life it is fluid, but of different degrees of thickness in different parts of the body. It is secreted from the blood, and is often suddenly reabsorbed into it, though pure oil is very rarely observed in the blood. It is indeed very probable, that oil, by digestion, partly in the primæ viæ, and partly in the lungs, is converted into gluten, and this again into oil by means of secretion; though no glandular organs secreting the fat can be shown by anatomists. It is, however, probable, that there are such organs; and that the cellular texture has some peculiar structure in those parts which are destined to contain the fat already secreted, without suffering it to pass into other places; for it never passes into those parts which are purely reticulated, although the cellular texture is easily permeable by air or water over the whole body from head to foot.

The fat is augmented by the use of much animal-food, or of any other that is oily and nourishing, provided the digestion be good; by the use of strong drink, especially malt-liquor; by much rest of body and mind, much sleep and inactivity, castration, cold, repeated blood-letting, and in general by whatever diminishes the vital and animal powers. Much, however, depends on the constitution of the body itself; nor is it possible to fatten a human creature at pleasure like an ox. A certain degree of fatness, according to the age of the person, is a sign and effect of good health; but when too great, it becomes a disease of itself, and the cause of other diseases. It may always be very certainly removed by strong exercise, little sleep, and a spare diet. The fat commonly makes up a considerable part of the bulk of the body, and sometimes by far the greatest part. Its use seems to be to make the motion of the body more easy and free, by lessening the friction of the moving parts, and thus preventing the abrasion of the solids, which would otherwise happen. It is also of use to hinder the parts from growing together, which sometimes happens, when by an ulcer or any other accident a part of the cellular texture containing the fat is destroyed. Besides all this, the fat contributes not a little to the beauty of the body, by filling up the large interstices between the muscles, which would otherwise give the person a deformed and shocking appearance. It is thought to be nutritious, when absorbed from its cells into the blood; but of this we have no certain proof. It seems to have some power of defending from the cold; at least, nature has bestowed it in very great quantity on those animals which inhabit the colder regions, as whales, bears, &c.

73
Vital solids.

Those parts of the body which enjoy sense and mobility, are called *living* or *vital* solids. They are the brain, cerebellum, medulla oblongata, spinal marrow, the nerves arising from these and diffused throughout the whole body, and which are distributed through the various organs of sense and through the muscles, and lastly the muscles themselves. Sensation is much more general than mobility, as being common to all the parts already mentioned. Mobility is proper to the muscular fibres alone: wherever there is sensation, therefore, we may believe that there are nerves; and wherever there is mobility, we may believe that muscular fibres exist. Nay, even mobility itself seems to originate from the connection which the muscles have with the nerves; for soon after the nerves are compressed, or tied, or cut, the muscles to which they are distributed lose their faculties; which happens too when the brain itself, or the origin of the nerves, is affected. Some reckon that the muscles are produced from the nerves, and consist of the same kind of matter. Both indeed have a similar structure, as being fibrous and of a white colour: for the muscles, when well freed from the blood, of which they contain a great abundance, are of this colour as well as the nerves; neither can the nervous fibres by any means be distinguished from the muscular fibres themselves. Both have also sensation; and both stimulants and sedatives act in the same manner, whether they be applied to the muscles themselves or to the nerves. These circumstances have led Dr Cullen and many others to consider the muscular fibre as being merely a continuation of nerve. But to this opinion there are many strong objections; though there can be no doubt that the contraction of the muscular fibre is intimately connected with nervous influence.

It is difficult for us to discover the origin of many parts of the body, or to ascertain whether they are produced all at the same time or one after another: yet it must be owned, that many of the muscular parts are observed to have attained a remarkable degree of

External Senses.

strength, while the brain is still soft and almost fluid: and that the action of these muscular parts is required for the action and growth of the brain. The muscles are also of a much firmer contexture than the nerves; and enjoy a power of their own, namely, that of irritability, of which the nerves never participate. Of necessity, therefore, either the muscles must be constructed of some kind of matter different from that of the nerves; or if both are made of the same materials, their organization must be exceedingly different. But if the substance of the muscles and nerves be totally different, we may easily be convinced that much of the one is always mixed with the other; for it is impossible to prick a muscle, even with the smallest needle, without wounding or lacerating many nervous fibres at the same time. Since, therefore, there is such a close connection between the muscles and nerves both as to their functions and structure, they are deservedly reckoned by physiologists to be parts of the same genus, called the *genus nervosum*, or *nervous system*.

74 Sense of feeling.

After treating of sense in general, Dr Gregory proceeds to consider particularly each of the senses both external and internal. He begins with the sense of feeling, as being the most simple, and at the same time in common to every part of the nervous system. In some places, however, it is much more acute than in others; in the skin, for instance, and especially in the points of the fingers. These are reckoned to have *nervous papillæ*, which by the influx of the blood are somewhat erected in the action of contact, in order to give a more acute sensation; though indeed this opinion seems rather to be founded on a conjecture derived from the structure of the tongue, which is not only the organ of taste, but also a most delicate organ of touch, than upon any certain observations.

75 Pain.

From the sense of feeling, as well as all the other senses, either pain or pleasure may arise; nay, to this sense we commonly refer both pain and almost all other troublesome sensations, though in truth pain may arise from every vehement sensation. It is brought on by any great force applied to the sentient part; whether this force comes from within or from without. Whatever, therefore, pricks, cuts, lacerates, distends, compresses, bruises, strikes, gnaws, burns, or in any manner of way stimulates, may create pain. Hence it is so frequently conjoined with so many diseases, and is often more intolerable than even the disease itself. A moderate degree of pain stimulates the affected part, and by degrees the whole body; produces a great flux of blood to the part affected, by increasing the action of its vessels; and it seems also to increase the sensibility of the part affected to future impressions. It often stimulates to such motions as are both necessary and healthful. Hence, pain is sometimes to be reckoned among those things which guard our life. When very violent, however, it produces too great irritation, inflammation and its consequences, fever, and all those evils which flow from too great force of the circulation; it disorders the whole nervous system, and produces spasms, watching, convulsions, delirium, debility, and fainting. Neither the mind nor body can long bear very vehement pain: and indeed Nature has appointed certain limits beyond which she will not permit pain to be carried, without bringing on delirium, convulsions, syncope, or even death, to rescue the miserable sufferer from his torments.

Long-continued pain, even though in a more gentle degree, often brings on debility, torpor, palsy, and rigidity of the affected part. But if not too violent, nor accompanied with fever, sickness, or anxiety, it sometimes seems to contribute to the clearness and acuteness of the judgment, as some people testify who have been afflicted with the gout.

76 Anxiety.

Anxiety is another disagreeable sensation, quite different from pain, as being more obtuse and less capable of being referred to any particular part, though frequently more intolerable than any pain. But we must take care to distinguish between this anxiety of which we treat in a medical sense, and that which is spoken of in common discourse. The latter does not at all depend on the state of the body, but belongs entirely to the mind; and arises from a sense of danger, or a foresight of any misfortune. The former is truly corporeal; and derives, no less than pain, its origin from a certain state of the body. Notwithstanding this difference, however, it is very possible for both these kinds of anxiety to be present at the same time, or for the one to be the cause of the other. A very great bodily anxiety will strike fear and despondency into the most resolute mind; and mental anxiety, on the contrary, if very violent and long-continued, may induce the former, by destroying the powers of the body, especially those which promote the circulation of the blood.

Anxiety, in the medical sense of the word, arises in the first place from every cause disturbing or impeding the motion of the blood through the heart and large vessels near it. Anxiety, therefore, may arise from many diseases of the heart and its vessels, such as its enlargement, too great constriction, ossification, polypus, palpitation, syncope, inflammation, debility, and also some affections of the mind. It is likewise produced by every difficulty of breathing, from whatever cause it may arise; because then the blood passes less freely through the lungs: anxiety of this kind is felt deep in the breast. It is said also to arise from the difficult passage of the blood through the liver or other abdominal viscera.

A certain kind of anxiety is very common and troublesome to hypochondriacal people; and arises from the stomach and intestines being either loaded with indigested and corrupted food, or distended with air produced by fermentation and extricated from the aliments. By such a load, or distention, the stomach, which is a very delicate organ, becomes greatly affected. Besides, the free descent of the diaphragm is thus hindered, and respiration obstructed. Anxiety of this kind is usually very much and suddenly relieved by the expulsion of the air; by which, as well as by other signs of a bad digestion, it is easily known. In these cases the anxiety is usually, though with little accuracy, referred to the stomach.

Anxiety also frequently accompanies fevers of every kind, sometimes in a greater and sometimes in a lesser degree. In this case it arises as well from the general debility as from the blood being driven from the surface of the body and accumulated in the large vessels: as in the beginning of an intermittent fever. Or it may arise from an affection of the stomach, when

when overloaded with crude, corrupted aliment; or distended and nauseated with too much drink, especially medicated drink. As the fever increases, the anxiety of the patient becomes greater and greater; remarkably so, according to the testimony of physicians, either immediately before the crisis or on the night preceding it; as before the breaking out of exanthemata, hæmorrhagy, sweat, or diarrhœa, which sometimes remove fevers. The patient feels likewise an anxiety from the striking in of any eruption or critical metastasis. This sensation also accompanies fevers and most other diseases, when the vital power is exhausted, and death approaches, of which it is the forerunner and the sign. It happens at that time, because the vital powers, unable to perform their functions, cannot make the blood circulate. But what kind of anxiety this is, the other signs of approaching death show very evidently. Moreover, even in the time of sleep, anxiety may arise from the same causes: hence frightful dreams, which frequently disturb our repose with surprise and terror.

77 Itching.

Itching, an uneasy sensation, with a desire of scratching the place affected, is often very troublesome, although it seems to be more a-kin to pleasure than to pain. As pain proceeds from too great an irritation, either chemical or mechanical, so does itching proceed from a slight one. Titillation, or friction, of a woollen shirt, for instance, upon the skin of a person unaccustomed to it, and of a delicate constitution, excites itching; as do also many acrid fossils, vegetables, and animals. Hence an itching is the first sensation after the application of cantharides, although the same, when augmented becomes painful. The same effect is produced by any thing acrid thrown out upon the skin; as in exanthematic fevers, the disease called the *itch*, &c. Lice, worms, especially ascarides, irritating either the skin or the intestines, excite a troublesome itching.

Too acute a sensation over the whole body is very rarely if ever observed. In a particular part the sense of feeling is often more acute than it ought to be, either from the cuticle itself being too thin and soft, or being removed; or from the part itself being inflamed, or exposed to too great heat. It becomes obtuse, or is even quite destroyed over the whole body, or in great part of it, from various affections of the brain and nerves; as when they are wounded, compressed, or defective in vital power. This is called *anæsthesia*, and sometimes accompanies palsy.

This sense may be deficient in a particular part, either from the nerve being diseased, or from its being compressed or wounded, or from the part itself being exposed to too great a degree of cold;—or from the scarf-skin which covers it being vitiated, either becoming too thick or hard, by the handling of rough, or hard, or hot bodies, as is the case with glass-makers and smiths; or from the elevation of the cuticle from the subjacent cutis, or true skin itself, by the interposition of blood, serum, or pus; or from the cutis being macerated, relaxed, or become torpid, which sometimes happens to hydropic persons; or lastly, from the whole organ being corrupted by gangrene, burning, cold, or contusion. This sense is very rarely depraved, unless perhaps in the case of delirium, when all the functions of the brain are disturbed in a surprising manner.

External Senses.

78 Taste.

The sense next to be considered is that of taste, the principal organ of which is the tongue; the nearer the tip of it, the more acute is the sense, and the nearer the glottis so much the more obtuse. It must be owned, however, that some kind of acrid substances, the taste of which is scarcely perceived upon the tip of the tongue, excite a most vehement sensation about its roots, or even in the throat itself. The tongue is endowed with many large and beautiful nervous papillæ, which seem to be the chief seat of this sense, and in the act of tasting are elevated and erected, in order to give the more acute sensation.

Nothing can be tasted which is not soluble in the saliva, that, being applied in a fluid form, it may pervade the involucra of the tongue, and affect its nervous pulp; and hence insoluble earths are quite insipid. Neither is it sufficient for a body to be soluble that it may be tasted: it must also have something in it saline, or at least acrid, in order to stimulate the nervous substance; and hence, whatever has less salt than the saliva is totally insipid.

The taste is rarely found to be too acute, unless through a fault in the epidermis which covers the tongue. If this be removed or wounded, or covered with ulcers, aphthæ, &c. then the taste, becoming too acute, is painful: or sometimes, no other sensation than that of pain is felt. It may be impaired, as well as the sense of feeling, from various diseases of the brain and nerves; of which, however, the instances are but rare. In some people it is much more dull than in others; and in such the sense of smelling is usually deficient also. The taste is most commonly deficient on account of the want of saliva; for a dry tongue cannot perceive any taste: hence this sense is very dull in many diseases, especially in fevers, catarrhs, &c. as well on account of the defect of saliva as of appetite, which is of so much service in a state of health; or by reason of the tongue being covered with a viscid mucus.

The taste is frequently depraved; when, for example, we have a perception of taste without the application of any thing to the tongue; or if any thing be applied to it, when we perceive a taste different from what it ought to be. This happens for the most part from a vitiated condition of the saliva, which is itself tasted in the mouth. Hence we may perceive a sweet, saline, bitter, putrid, or rancid taste, according to the state of the saliva: which may be corrupted either from the general vitiated condition of the mass of humours, or the glands which secrete it; of the mouth itself; or even of the stomach, the vapours and eructations of which rise into the mouth, especially when the stomach is diseased.

Besides the faults of the saliva, however, the taste may be vitiated from other causes; as, for instance, the condition of the nervous papillæ. This, however, is as yet but little known to us; for the taste is sometimes plainly vitiated, when at the same time the saliva appears quite insipid when tasted by other people.

Physicians, in almost every disease, but especially in fevers, inquire into the state of the tongue; not, indeed, without the greatest reason: for from this they can judge of the condition of the stomach; of the thirst, or rather the occasion the patient has for drink, when, on account of his delirium or stupor, he neither feels his thirst,

External Senses.

thirst, nor is able to call for drink. And, lastly, from an inspection of the tongue, physicians endeavour to form some judgment concerning the nature, increase, and remission of the fever.

79 Smell.

After the sense of taste, we shall next treat of that of that smell. Its seat is in that very soft and delicate membrane, filled with nerves and blood-vessels, which covers the internal parts of the nose, and the various sinuses and cavities proceeding from thence. This sense is more acute about the middle of the septum, and the *ossa spongiosa*, where the membrane is thicker and softer, than in the deeper cavities, where the membrane is thinner, less nervous, and less filled with blood-vessels; although even these do not seem to be altogether destitute of the sense of smelling.

As by our taste we judge of the soluble parts of bodies, so by our smell we judge of those very volatile and subtile parts which fly off into the air; and like the organ of taste, that of smell is kept moist, that it may have the more exquisite sensation, partly by its proper mucus, and partly by the tears which descend from the eyes.

Some kinds of odours greatly affect the nervous system, and produce the most surprising effects. Some gratefully excite it, and immediately recruit the spirits when almost sinking; while some produce fainting, nay, as it is alleged, even sudden death. To this head also are we to refer those antipathies, which, though truly ridiculous, are often not to be subdued by any force of mind.

This sense is sometimes too acute, as well from some disease in the organ itself, which happens more rarely, as from the too great sensibility of the nervous system in general, as is sometimes observed in nervous fevers, phrenitis, and hysteria. It is more frequently, however, too dull, either from diseases of the brain and nerves, as from some violence done to the head, or from some internal cause; or it may proceed from a dryness of the organ itself, either on account of the customary humours being suppressed or turned another way, or from the membranes being oppressed with too great a quantity of mucus or of tears. Of both these cases we have instances in the cattarh, where at first the nostrils are dry, but afterwards are deluged with a thin humour, or stopped up with a thick one. But in these, and many other examples, the membrane of the nose itself is affected with inflammation, relaxation, or too great tension, by which the nerves, which constitute a great part of it, must be vitiated. It is evident also, that whatever obstructs the free entrance of the air into the nostrils, or impedes its passage through them, must prove detrimental to the sense of smelling.

80 Hearing.

The sense of hearing is more frequently vitiated than almost any of the rest, as having a more delicate organ, and one composed of many and very small parts, of which an account is given under the article ANATOMY.—It frequently becomes too acute; either from the general habit of the body being too irritable, such as often happens to hysterical and lying-in-women; or from too great a sensibility of the brain itself, which is not unfrequently observed in fevers, as well as in phrenitis, and sometimes in the true mania; or it may be from a disease of the ear itself, as when it is affected with inflammation, pain, or too great tension.—It may be rendered dull, or even be altogether destroyed, so that the person shall become totally deaf, from the same causes acting with different degrees of force. This happens especially from the want of the external ear; or from the meatus auditorius being stopped up with mucus, wax, or other matters; or from the sides of the canal growing together, as sometimes happens after suppuration or the small-pox; or by the membrane of the tympanum becoming rigid or relaxed, or being eroded or ruptured; or the tympanum itself, or the Eustachian tube, may from certain causes be obstructed; or some of the little bones or membranes, or some of the muscles of the labyrinth, may be affected with concretion, spasm, palsy, or torpor; or, lastly, it may happen from diseases of the brain and nerves, all the organs of hearing remaining sound. Hence deafness is often a nervous disease, coming suddenly on, and going off spontaneously. Hence also it is common in old people, all of whose solid parts are too rigid, while their nervous parts have too little sensibility.

Persons labouring under fevers, especially of the typhus kind, often become deaf. When this comes on along with other signs of an oppressed brain, and a great prostration of health, it may be a very bad symptom; but for the most part it is a very good one, even though accompanied with some degree of torpor or sleepiness.

A very common disease in the sense of hearing is when certain sounds, like those of a drum, a bell, the falling of water, &c. are heard without any tremor in the air, or without a sound person's hearing any thing. This disease is called *tinnitus aurium*, of which various kinds have been observed. For the most part it is a very slight transient disorder; but sometimes it is most obstinate, long-continued, and troublesome. It often arises from the slightest cause, such as any thing partially stopping up the meatus auditorius or Eustachian tube itself, so that access is in part denied to the air; whence it happens that the latter strikes the membrane of the tympanum, or perhaps the interior parts, unequally, and with too much force. Hence *bombi*, a kind of tinnitus, are heard even by the most healthy when they yawn.

A much more frequent and troublesome species of tinnitus accompanies many diseases both of the febrile and nervous kind. This is occasioned partly by the increased impetus of the blood towards the head, with an increase of sensibility in the nervous system itself, so that the very beatings of the arteries are heard; and partly from the increased sensation and mobility of the nerves and muscles of the labyrinth: whence it happens, that the parts which ought to be at rest until excited by the tremor of the air, begin to move of their own accord, and impart their motion to other parts which are already in a morbid state of too great sensibility.

A tinnitus sometimes arises from any vehement affection of the mind; sometimes from a disorder in the stomach; sometimes from a rheumatic disorder affecting the ears and head; or from a catarrh, which commonly affects the Eustachian tube. Sometimes, however, the tinnitus alone affects the patient; and even this is a disease of no small consequence. These various causes, however, both of this and other disorders of the hearing,

hearing, are often very difficult to be distinguished, as well on account of the inaccessible situation of the organ, as on account of the little knowledge we have of its action. But from whatever cause it arises, both this and the other affections of the hearing can neither be cured certainly nor easily, but by the removal of the cause whatever it may be.

Of sight.

Concerning the nature of the sense of sight, the reader may consult the articles ANATOMY and OPTICS. Of this sense some slight disorders, or rather varieties, are often observed. Those persons are called *short-sighted* who cannot see distinctly unless the object be very near them. This disorder arises from too great a refraction of the rays by reason of their being too soon collected into a focus by the crystalline lens, and diverging again before they fall upon the retina, by which means they make an indistinct picture upon it. The most common cause is too great a convexity of the eye or some of its humours, as too prominent a cornea. It is a disorder common to young people, which is sometimes removed when they grow older. As soon as the first approaches of short-sightedness are observed, it is supposed it may be obviated by the person's accustoming himself to view remote objects, and keeping his eyes off very small and near ones: as, on the contrary, it may be brought on by the opposite custom; because the eye accommodates itself somewhat to the distances of those objects which it is accustomed to view. But a concave glass, which causes the rays of light to diverge more than naturally they would before falling upon the cornea, is the most simple and certain remedy.

Long-sighted people are those who cannot see an object distinctly unless it be at a considerable distance from them. This arises from causes contrary to the former; namely, the eye being too flat, so that there is no room for refracting the rays and bringing them into a focus. Hence this defect is common in old people, and remedied by the use of convex glasses.

Those are called *nyctalopes* who see better with a very weak than with a strong light. It is a defect very seldom to be met with in the human race, though every person is sensible of it who hath been long kept in the dark and is then suddenly brought into the light. The disease arises from too great a sensibility of the retina, and the pupil being too open.

The sight is liable to many and grievous disorders. It is sharpened beyond measure, so that the person either perceives nothing distinctly or with great pain, from the same causes that induce a similar disorder in the other senses; namely, excessive sensibility in the general habit of body; or a particular state of the brain common in phrenitis, or even in those afflicted with fevers arising from inflammation or too great excitement; though more frequently from the condition of the eye itself, one becomes unable to bear the light. The inflammation of the tunica adnata, and the forepart of the sclerotica, is communicated to the back parts of it, and from thence to the choroides and retina itself. Hence the light becomes intolerable, and vision is attended with pain and great irritation, sometimes inducing or augmenting a delirium.

The sense of seeing is made dull, or even totally abolished, by age; the aqueous humour not being supplied in sufficient quantity, and the cornea and lens, or the vitreous humour, becoming shrivelled or decayed. It may likewise happen from the cornea becoming dry and opaque; which is to be imputed to the languid motion of the blood, and to great numbers of the small vessels being obstructed or having their sides concreted;—or from the crystalline lens becoming yellow like amber, and the retina itself less sensible, for old age diminishes every sensation. It is totally abolished by injuries of the brain, the optic nerve, or the retina, even though the structure of the organ should remain sound. This disease is called an *amaurosis;* and is easily known by the dilatation and immobility of the pupil, the humours of the eye remaining clear. It is commonly owing to congestion of blood; and sometimes, where no congestion of blood can be discovered, to mere torpor of the nerves. If it be only a torpor of part of the retina, we see black spots in those things at which we look; or flies seem to pass before our eyes, a very bad sign in fevers, and almost always mortal. The sight is abolished also by the obscurity or opacity of any of the parts through which the rays ought to pass and be refracted; as if the cornea lose its transparency by being covered with spots; or the aqueous humours become corrupted with blood, serum, or pus; or the lens (which often happens, and which is called a *cataract*) becomes of a gray or brown colour, or the vitreous humour be in like manner corrupted; or, lastly, when all the humours being dissolved, confused and mixed together, by inflammation and suppuration, either do not suffer the light to pass at all, or to pass imperfectly and unequally; whence either no image is formed on the retina, or it appears obscure, distorted, imperfect, and ill-coloured.

The sight is also depraved, when things appear to it of a colour different from their own, or even in another situation and of another shape than they ought to have. This happens from the humour being tinctured with any unusual colour, as is said to happen in some instances of jaundice; or from an extravasation and mixture of the blood with the aqueous humour. A surprising depravation also, or constant and perpetual defect of vision, is not unfrequently observed in men otherwise very healthy, and who see quite clearly; namely, that they cannot distinguish certain colours, green, for example, from red. Another depravation is, when, without any light being admitted to the eyes, sparks, small drops of a flame or gold colour, and various other colours, are observed to float before us. This is generally a very slight and transient disorder, common to those whose constitutions are very irritable; and arises from the slight impulse, as it would seem, on the retina, by the vessels beating more vehemently than usual. A fiery circle is observed by pressing the eye with the finger after the eyelids are shut. The same reason, perhaps, may be given for those sparks which are seen by persons labouring under the falling sickness, and increasing to the size of an immense and luminous beam before they fall down in convulsions. A similar beam those who have recovered from hanging or drowning testify that they have observed: for by reason of the respiration being suppressed, the vessels of the head swell and compress the whole brain and nervous parts of the head. Sparks of the same kind, and these too of no good omen,

External Senses.

omen, are observed in patients labouring under a fever, where a phrenitis or fierce delirium is at hand; and likewise in those who are threatened with palsy, apoplexy or epilepsy.—A distinct but false perception, namely of visible things which do not exist, is to be imputed to some injury of the brain, to madness or a delirium, not to any disease of the eye.

A very frequent defect of vision remains to be mentioned, namely, squinting. A person is said to squint who has the axes of the eyes more oblique than usual, and directed to different points. Hence a great deformity, and often an imperfect and confused vision by which the objects are sometimes seen double. It is an evil for the most part born with the person, and often corrected by those attempts which an infant makes to see more pleasantly and distinctly; and this even without being conscious of its own defects. It is also easily learned, especially in infants, even without their own knowledge, by that kind of imitation which has a great influence over the human race, especially in their tender years.—It is by no means, however, so easily unlearned.

Squinting is frequently occasioned by a spasm, palsy, rigidity, &c. of the muscles which manage the eye; by epilepsy; by certain diseases of the head, the hydrocephalus especially; or by any great injury done to the head. Sometimes, though very rarely, it comes on suddenly without any known cause. It is very probable, however, that squinting often arises from a fault of the retinæ, when their central points, for instance, and those similarly placed with respect to the centre, do not agree. In this case there must be a contortion of the eye, that the object may not be seen double. This seems also to be the reason why squinting is much increased when the person brings the object near his eye in order to view it more perfectly. Or if the central point of either, or both, of the retinæ be insensible, or nearly so, it is necessary for the person to distort his eyes that he may have any distinct vision of objects. If the optic nerve had not entered the retina obliquely, but passed directly through its centre, we would all either have squinted or seen double.

82 Vertigo.

Physicians have referred to the sense of vision that most troublesome sensation which we call a *vertigo;* though it seems rather to belong to that of feeling, or of consciousness; for in many instances the disorder is not removed either in the dark or by shutting the eyelids. The vertigo takes place when external objects really at rest seem to reel, to whirl round, to tremble, or to move in any manner of way. If the disorder be very violent, the person is neither able to see, on account of a dimness of sight; nor can he stand, as the powers fail which ought to govern the limbs. A nausea also usually accompanies the vertigo, and the one generally produces the other.

This disorder is observed to be both the symptom and forerunner of some dangerous diseases; such as apoplexy, epilepsy, hysteria; hæmorrhages from the nose and other parts; suppressions of the menses; plethora; fevers, as well such as are accompanied with debility as those in which there is an increased impetus of the blood towards the head. An injury done to the head also, but rarely one done to the eyes, unless as it affects the whole head, brings on a vertigo. A vertigo may be likewise produced by a very great and sudden loss of blood or other fluid; by debility; syncope; various diseases of the alimentary canal, of the stomach especially; poisons admitted into the body, particularly of the narcotic kind, as opium, stramonium, wine, &c. and hence vertigo is a symptom of every kind of drunkenness. Various motions also, either of the head or the whole body, being tossed in a ship, especially if the vessel be small and the sea runs high, produce a vertigo. In these and similar examples, the unusual and inordinate motions of the blood are communicated to the nervous parts which are in the head; or these being affected by sympathy from the neighbouring parts, produce a confused sensation as if of a rotatory motion. Nay, it is often produced from an affection of the mind itself, as from beholding any thing turned swiftly round, or a great cataract, or looking down a precipice, or even by intense thought without looking at any thing.

Though a vertigo be for the most part a symptom and concomitant of other diseases, yet it is sometimes a primary disease, returning at intervals, increasing gradually, and equally impeding and destroying the functions of the body and mind.

83 Memory.

After having treated of the external senses, we shall next proceed to consider those properly called *internal;* which are the *memory*, the *imagination*, and the *judgement*. The first is lessened, disturbed, or even totally destroyed, in many diseases, especially those which affect the brain; as in apoplexy, palsy, internal tumours of the head, external violence applied, fevers, especially those in which there is an increased motion of the blood towards the head, or where the brain is any other way very much affected. It is very rarely, however, depraved in such a manner that ideas are not represented to the mind in their proper order; or if at any time such a disorder occurs, it is considered rather as a disorder of the imagination, or as a delirium, than a failure of the memory. The mind is said to be disordered when the perceptions of memory or imagination are confounded with those of sense, and of consequence those things believed to be now present which are really past or which never existed; or when the sense of the person concerning ordinary things is different from that of other people. The general name for such disorders is *vesania:* if from fever, it is called *delirium*. A general fury without a fever, is called *mania* or *madness:* but a partial madness, on one or two points, the judgment remaining sound in all other respects, is called *melancholia*. There is, however, no exact and accurate limits between a sound mind and madness. All immoderate vivacity borders upon madness; and, on the other hand, a sorrowful and gloomy disposition approaches to melancholy.

84 Delirium.

Delirium accompanies fevers of many different kinds. Sometimes it is slight, easily removed, and scarce to be accounted a bad sign. Often, however, it is very violent, and one of the very worst of signs, requiring the utmost care and attention.

A delirium is either fierce or mild. The fierce delirium is preceded and accompanied by a redness of the countenance, a pain of the head, a great beating of the arteries, and noise in the ears; the eyes in the mean time looking red, inflamed, fierce, shining, and unable to bear the light; there is either no sleep at all, Delirium.

all; or sleep troubled with horrid dreams; the wonted manners are changed; an unusual peevishness and ill-nature prevail. The depravation of judgment is first observed between sleep and waking, and by the person's crediting his imagination, while the perceptions of sense are neglected, and the ideas of memory occur in an irregular manner. Fury at last takes place, and sometimes an unusual and incredible degree of bodily strength, so that several attendants can scarce keep a single patient in his bed.

The mild delirium, on the contrary, is often accompanied with a weak pulse, a pale collapsed countenance, and a vertigo when the patient sits in an erect posture; he is seldom angry, but often stupid, and sometimes remarkably grieved and fearful. The loss of judgment, as in the former kind, is first perceived when the patient is half awake; but a temporary recovery ensues upon the admission of the light and the conversation of his friends. The patient mutters much to himself, and attends little to the things around him; at last, becoming quite stupid, he neither feels the sensations of hunger or thirst, nor any of the other propensities of nature, by which means the urine and excrements are voided involuntarily. As the disorder increases, it terminates in subsultus tendinum, tremors, convulsions, torpor, and death. The other species of delirium also frequently terminates in death, when the spirits and strength of the patient begin to fail.

The symptoms accompanying either of these kinds of delirium show an unusual, inordinate, and unequal motion of the blood through the brain, and a great change in that state of it which is necessary to the exercise of the mental powers. It is very probable, that an inflammation of the brain, more or less violent and general, sometimes takes place, although the signs of universal inflammation are frequently slight. This we learn from the dissection of dead bodies, which often show an unusual redness of the brain or of some of its parts, or sometimes an effusion or suppuration.

The state of the brain, however, may be much affected, and delirium induced, by many other causes besides the motion of the blood. In many fevers, typhus, for instance, the nervous system itself is much sooner and more affected than the blood's motion; and though the morbid affections of the nervous system are as invisible to the senses as the healthy state of it, the symptoms of its injuries plainly show that its action, or *excitement*, as some call it, is unequal and inordinate. In this way, too, delirium is produced by several poisons.

Melancholy and mania.

The pathology of melancholy and mania is much more obscure; as coming on without any fever, or disturbance in the blood's motion. Often also they are hereditary, depending on the original structure of the body, especially of the brain; the fault of which, however, cannot be detected by the nicest anatomist. But it is well known, that various diseases of the brain, obstructions, tumors, either of the brain itself, or of the cranium pressing upon it, any injury done to the head, and, as some physicians relate, the hardness and dryness of the brain, and some peculiar irritations affecting the nervous system, are capable of bringing on this malady. And indeed so great are the irritations affecting the nervous system in mad people, that they often sleep little or none for a long time.—Yet even this so defective and imperfect knowledge of the diseases of the brain and nerves, is by no means free from difficulties. For though we know that the brain, or a certain part of it, is hurt, or that it is irritated by a swelling, or a pointed bone growing into it, nobody can foretel how great, or what may be the nature of the malady from such a hurt: for examples are not wanting of people who, after losing a large part of the brain, have recovered and lived a long time; there are many instances also of persons who have perceived no inconvenience from a large portion of that viscus being corrupted, until at length they have fallen suddenly down and died in convulsions.

86 Idiotism.

Another disease of the internal senses, quite different from these, is *fatuity* or *idiotism*. Those are called *idiots* who are destitute either of judgment or memory, or else have these faculties unequal to the common offices of life. A weak memory, however, is by no means essential to idiotism. For there are some instances of idiots who have had very correct and very extensive memories. A kind of idiotism is natural and common to all infants; neither is it to be accounted a disease; but if it last beyond the state of infancy, it is a real disease, and for the most part incurable. It has the same causes with the other diseases of the internal senses; although these can scarcely be detected by the eye or by the knife of the anatomist. It frequently accompanies, or is the effect of, epilepsy. Hence, if the epilepsy derives its origin from causes not seated in the head, as from worms lodging in the intestines, the fatuity may be cured by dislodging these, and removing the epilepsy. It is not unlikely that the fatuity of children, and the dotage of old men, may arise from the brain being in the former too soft and in the latter too hard; or perhaps in the one case not evolved, and in the other somewhat decayed.

87 Disorders in the muscular power.

The muscular power may be diseased in a great number of ways. The mobility itself may be too great; but this must be carefully distinguished from vigour. By mobility is meant the ease with which the muscular fibres are excited into contraction. The vigour, on the other hand, is that power with which the contraction is performed. They are sometimes joined, but more frequently separate, and for the most part the excesses of each are owing to contrary causes.

88 Mobility.

Too great mobility is when motions are excited by a very slight stimulus, or when very violent motions are produced by the customary stimulus. A certain habit of body, sometimes hereditary, renders people liable to this disease. Women have a greater share of mobility than men. Infants have a great deal of mobility, often too great; youth has less than infancy, but more than man's estate; though old age has commonly too little. A lazy, sedentary life, full diet, a suppression of the usual evacutions, fulness of the blood-vessels, and sometimes their being suddenly emptied, laxity, flaccidity of the solids in general, but sometimes too great a tension of the moving fibres, the use of diluents, especially when warm, or heat applied in any manner, produce too great mobility. And this may be either general or particular, according as the causes have been applied to the whole body, or only to a part of it.

89 Vigour.

Vigour in general is rarely morbid; although sometimes certain muscular parts appear to have too great strength. In maniacs and phrenitics, an immense strength

Disorders in the Muscular Power.

strength is observed in all the muscles, especially in those which serve for voluntary motion; this is not unjustly reckoned morbid. The reason of this excess is very obscure; however, it is plainly to be referred to a diseased state of the brain.

A more frequent and more important excess of vigour is observed in those muscular fibres that do not obey the will, such as those which move the blood. Its circulation is thus often increased, not without great inconvenience and danger to the patient. But a slighter excess of this kind, pervading the whole body, renders people apt to receive inflammatory diseases, and is usually called a *phlogistic diathesis*. But this is better observed when local, as in inflammation itself.

Too great vigour of the muscular fibres may arise from the nervous power increased beyond measure, as in mania, phrenitis, or violent affections of the mind; from too great a tension of the fibres, by which they more easily and vehemently conceive motions, as of the arteries when filled with too much blood; from catching cold, by being exposed either to cold or heat, as usually happens in the spring; or, lastly, though the nervous power and tension of the fibres should not at all be changed, their action may become too great, from a stimulus more violent than usual being applied, or from the usual stimulus, if the fibres themselves have already acquired too great a share of mobility.

90 Torpor.

The opposite to too great mobility is torpor, and to too great vigour is debility. Torpor is such a diminution of mobility as renders the parts unequal to their functions. It arises from causes directly opposite to mobility; such as, a harder and more rigid contexture of the parts themselves, or even sometimes from one too lax and flaccid; from old age; from some peculiar temperament of body, such as one phlegmatic, frigid, or insensible; too great and incessant labour, cold, spare diet, and an exhausted body. This evil is the more to be dreaded, because, the powers of the body being deficient, nature is neither able to make any effort of herself, nor are the remedies, in other cases the most efficacious, capable of affording her any assistance.

91 Debility.

Debility takes place, when the motion of the muscles, either voluntary or involuntary, is not performed with sufficient strength. A greater or lesser share of debility, either general or of some particular part, accompanies almost all diseases, and is indeed no small part of them: for it is hardly possible that a disease can subsist for any length of time without inducing some degree of debility. When a state of debility is induced, it renders a man obnoxious to innumerable disorders, and throws him as it were defenceless in their way. It often depends on the original structure of the body, so that it can be corrected neither by regimen nor medicines of any kind. A different degree of strength also accompanies the different ages of mankind; and thus, in some cases, debility cannot be reckoned morbid. But a truly morbid and unusual debility arises from the nervous energy being diminished; from diseases of the brain and nerves, or of the muscles through which they are distributed; from a decay of the nerves themselves; from a want of the due tension of the fibres, or the fibres themselves becoming torpid; from the body exhausted by spare diet, want, evacuations; or, lastly, from diseases affecting the whole body, or some particular parts of it.

92 Palsy.

The highest degree of debility, namely, when the strength of the muscles is altogether or nearly destroyed, is called *paralysis* or *palsy*; and is either universal, or belonging only to some particular muscles. An universal palsy arises from diseases of the brain and nerves, sometimes very obsure, and not to be discovered by the anatomist; for the nervous power itself is often deficient, even when the structure of the nerves remains unhurt; yet often a compression, obstruction, or injury of the vesssels, extravasation of blood or serum, collections of pus, swellings, &c. are discovered. It frequently arises from certain poisons acting on the nerves; from the fumes of metals; from the diseases of parts, and affections of the muscles, very remote from the brain, as in the colic of Poictou. A palsy of single muscles, but less perfect, often arises without any defect of the brain or nerves, from any violent and contained pain, inflammation, too great tension, relaxation, rest, or destruction of the texture of the parts, such as commonly happens after the rheumatism, gout, luxations, fractures of the bones, and ischuria.

An *universal* palsy, however, as it is called, seldom affects the whole body, even though it should originate from a disease of the brain. We most commonly see those who are paralytic affected only on one side, which is called an *hemiplegia*. It is said that the side of the body opposite to the diseased side of the brain is most commonly affected. If all the parts below the head become paralytic, it is called a *paraplegia*. In these diseases the senses for the most part remain; though sometimes they are abolished, and at others rendered dull. Sometimes, though rarely, and which is an exceeding bad symptom, the motion, sensation, pulse, and heat of the paralytic limbs are lost; in which case the arteries themselves become paralytic. A palsy of the whole body, as far as regards the voluntary motions, with anæsthesia and sleep, is called an *apoplexy*. This proceeds from some injury of the brain: though a state very similar to it is induced by narcotics. opium, wine itself, or any generous liquor taken to excess; and lastly, by breathing in air corrupted by noxious impregnations, such as a large proportion of carbonic acid, hydrogenous gas, or similar active aeriform fluids.

Another disease to which muscular motion is liable, and that neither slight nor unfrequent, is called *spasm*. This is a violent and irregular motion of the muscles. Of spasms there are two kinds, the tonic and clonic. The latter is frequently called a *convulsion;* in order to distinguish it from the other, which is more peculiarly called *spasm*. Spasm.

Spasm, therefore, is a violent, constant and preternatural contraction of the muscular fibres; but a convulsion is an unusual and violent contraction alternated with relaxation. People are rendered liable to spasm by too sensible a habit of body, or too great mobility; and hence it is a disease common in women, in infants, and in weak, luxurious, lazy, and plethoric people. It is brought on those already predisposed to it, by any kind of stimulus applied to the brain, or to any nerve, muscle, or nervous part connected with it:

of

of which we have examples in dentition; worms lodged in the intestines, and irritating them; any acrid matter infecting the blood, or much affecting the stomach and intestines; the irritation of any nerve, or of the brain itself, by an exostosis, swelling, too great fulness of the vessels, pain, vehement affections of the mind, sudden evacuation, or poisons admitted into the body. Frequently, however, the malady originates from slight causes, little known, and not easily observed.

Spasm is both the cause and effect, and frequently constitutes the greatest part, of many diseases. It is often very difficult either to be known or cured; because it is so multiform, and produces as many different symptoms as there are organs affected; of which it surprisingly disturbs, impedes, or increases the functions. It is a disease seated in the original stamina of the constitution; and neither to be removed by slight remedies, nor in a short time.

With regard to sleep, its use is sufficiently apparent from the effects which it produces in the body. It restores the powers both of mind and body when exhausted by exercise, giving vigour to the one, and restoring its wonted alacrity to the other. It renders the muscles again active and moveable, after they have become wearied, rigid, painful, and trembling by hard labour. It moderates the quickness of the pulse, which usually increases at night, and brings it back to its morning standard. It seems also to assist the digestion of the aliment; lessens both the secretions and excretions; and renders the fluids thicker than otherwise they would be, especially in a body endowed with much sensibility and mobility. Hence sleep is not only useful, but absolutely necessary for preserving life and health; and is a most excellent remedy both for alleviating, and totally removing, many diseases.

Want of sleep is hurtful in many different ways, especially to the nervous system. It renders the organs of sense both external and internal, as well as those of every kind of motion, unfit for performing their offices. Hence the sensations are either abolished, or become imperfect or depraved; and hence imbecility of mind, defect of memory, a kind of delirium, mania itself, pain of the head, weakness of the joints, an imperfect or inordinate action of the vital organs, quickness of pulse, heat, fever, depraved digestion, atrophy, leanness, and an increase or perturbation of the secretions and excretions.

Sleep may be prevented both in healthy and sick people from various causes; such as strong light, noise, pain, anger, joy, grief, fear, anxiety, hunger, thirst, vehement desire, motion of the body, memory, imagination, intense thought, &c. On the other hand, sleep is brought on by a slight impression on the organs of sense, or none at all; by the humming of bees, the noise of falling water, cold and insipid discourse; or lastly, by such an exercise of the memory as is neither too laborious nor disturbing to the mind.—Too great an impulse of the blood towards the head, such as often happens in fevers, prevents sleep; but a free and equal distribution of the blood through the whole body, especially the extreme parts, frequently brings it on. Whatever weakens the body also favours sleep; and hence various kinds of evacuations, the warm bath, fomentations, sometimes heat itself, are useful for promoting it. It also comes on easily after taking food, or indulging venery; the violent sensation being then quieted, and the body itself somewhat weakened. Cold produces a deep sleep of long continuance, not easily disturbed, and often terminating in death. Lastly, There are certain substances which, when applied to the body, not only do not excite the nervous system, but plainly lay us asleep, and render us unfit for sensation; of this kind are those called *narcotics*, as opium and the like; among which also we may reckon wine taken in too great quantity. Lastly, Watching itself is often the cause of sleep; because while a man is awake he always more or less exercises the organs of his body, by which the nervous influence is diminished, and thus the more violently the body is exercised, in the same proportion is the person under a necessity of sleeping.

Sleep is deficient in many diseases; for there are few which do not excite pain, anxiety, or uneasiness, sufficient to prevent the approach of sleep, or to disturb it. Fevers generally cause those who labour under them to sleep ill; as well on account of the uneasiness which accompanies this kind of disease, as by reason of the impetus of the blood towards the head being frequently increased; and likewise from the stomach being disordered, loaded with meat, or distended with drink. Hence also we may see the reason why many hypochondriac and hysteric patients sleep so ill; because they have a bad digestion, and their stomach is disposed to receive many though frequently slight disorders; the slightest of which, however, is sufficient to deprive the patient of rest, provided the body be already irritable, and endowed with too great a share of mobility.

Want of sleep will hurt in diseases as well as in health; and for the same reason; but in a greater degree, and more quickly, in the former than in the latter; and is therefore not only a very troublesome symptom of itself, but often produces other very dangerous ones.

Too much sleep, on the other hand, produces many mischiefs, rendering the whole body languid, torpid, and lazy; and it even almost takes away the judgment. It also disturbs the circulation, and diminishes most of the secretions and excretions. Hence plethora, fatness, flaccidity, and an inability for the common offices of life.—The causes of this excess are, either the usual causes of sleep above mentioned increased beyond measure, or some fault in the brain, or a compression of it by an extravasation of the humours; or sometimes, as it would seem, from great debility produced by an unusual cause, as in those who are recovering from typhous fevers and other diseases. In these examples, however, this excess of sleep is by no means hurtful; nor even, perhaps, in those cases where an excess of grief continued for a long time, or a great fright, have produced a surprising and unexpected somnolency. Lastly, Many people have accustomed themselves, and that not without a great deal of hurt to their constitutions, to sleep too much. Nor are there examples wanting of some who have passed whole days, and even months, in sleep almost uninterrupted.

95 Circulation.

With regard to the manner in which the circulation of the blood is performed, and the various principles of which it is composed, see the articles Blood, and Anatomy. As for the disorders to which the blood and its circulation are subject, it has been observed, that

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that in our younger years the veins are much more dense, firm, and strong, than the arteries; but the latter, by reason of the continual pressure upon them, and the strength which they exert, become daily more firm, hard, and strong, until at last they equal or exceed the veins themselves in strength; and it is not uncommon in old men to find some part of the arteries converted into a horny substance, or even into a solid bone. Hence in the state of infancy the greatest part of the blood is contained in the arteries, and in old age in the veins; an affair indeed of no small moment, as it shows the reason, in some measure, of the state of increase and decrease of the body. Besides, if any disease happens from too great a quantity of blood, it thence appears that it must show itself in young subjects in the arteries, and in old ones in the veins; and this is the reason of many diseases which accompany certain periods of life.

In most, if not in all species of animals, the arteries of the females are much more lax and capacious when compared with the veins, and the veins much less, than in the males of the same genus. The design of nature in this conformation, is probably that they may be the better able to nourish the fœtus in their womb. The same likewise seems to be the reason why women are more inclined to plethora than men; and to this greater capacity of the arteries and smallness of the veins are we to ascribe that beauty and elegant shape of the arms in women, not disfigured or livid with veins as in men.

The blood is also distributed in various proportions to the different parts of the body, and that proportion too differs at different periods of our lives. At first a great quantity is sent to the head, because that part of the body is first to be evolved and fitted for its offices; but as soon as the parts begin to make a considerable resistance to the efforts of the blood, and the vessels cannot easily be further dilated, it is necessarily sent off to other parts; by which means the rest of the body increases in bulk, and becomes fitted for performing its proper functions. The effect of this change is also very soon observed, namely, when none of the blood passes through the navel, and of consequence a greater quantity is sent by the iliac arteries to the inferior extremities. These, though so small and slender in the fœtus, increase very suddenly; so that often in not many months, the child can not only stand on its feet, but even walk tolerably well. And during the earliest periods of infancy, the inferior extremities grow more rapidly than any other part of the body.

96
Pulsation of the arteries

Physicians are wont to judge of the state of the circulation by the pulse, which indeed is very various, as well with regard to its frequency, as to the strength and equality of its strokes and intervals.—Its common quickness in a healthy adult is about 70 strokes in a minute. In a fœtus, perhaps, it is more than double; and in an infant a few months old, hardly less than 120. As we grow up, this quickness gradually diminishes; so that in extreme old age it sometimes does not exceed 50, or is even slower. This rule, however, is not without exceptions: for many, especially those of an irritable habit, have the pulse much quicker; while others, even in the vigour of their age, have their pulse remarkably slow. It is for the most part somewhat quicker in women than in men.

The pulse is also rendered quicker, both in a healthy and diseased body, by the application of stimuli of many different kinds. Exercise especially, by accelerating the return of the blood through the veins, increases the quickness of the pulse to a surprising degree. Various kinds of irritations affecting the nervous system, as intense thinking, passions of the mind, pain, heat, stimulating medicines, wine, spices, &c. likewise produce the same effect. The acrimony of the blood itself also is thought to quicken the pulse.

When a person first awakes in the morning, the pulse is slow, but becomes quicker by degrees on account of the many irritating matters applied to the body. Its quickness is increased after taking food, especially of the animal kind, or such as is hot or seasoned with spices. In the evening a slight fever comes on, for which rest and sleep are the remedy. These things, however, are scarcely to be observed in a healthy person, but are very evident in one that is feverish, especially when the fever is a hectic.—Again, even debility itself often renders the pulse quicker than usual; because the ventricle of the heart not being quite emptied, it is the sooner dilated again, and of consequence contracts the sooner. For this reason a physician can never judge of the strength of the circulation from the frequency of the pulse.

Lastly, In all fevers, however different from one another, the pulse is found to be too quick, partly perhaps from debility, partly from the acrimony of the fluids, and partly from the repulsion of the blood from the surface of the body, and the accumulation of it in the large vessels where it acts as a stimulus; though it must be owned, that a great deal of this is obscure, if not totally unknown; nor in truth are we able to understand in what manner the *autocrateia* acts with regard to the frequency of the pulse.

The pulse is seldom observed too slow, unless when the mobility of the body is much diminished, as in decrepid old age, or from a compression or disease of the brain, as is exemplified in the second stage of hydrocephalus; but a greater compression of the brain usually produces a still more remarkable slowness of the pulse, as in the third stage of hydrocephalus.—Sometimes also the pulse is too slow in those who are recovering from tedious fevers. But this is a matter of little moment, and seems to be owing to some kind of torpor. Indeed it has generally been considered as a mark of a thorough and complete solution of the fever; for it is commonly observed, that when this state of the pulse takes place, the patient seldom suffers a relapse.

While the frequency of the pulse continues the same, its strokes may be either full, great, strong, and hard; or soft, small, and weak. A full, great, and strong pulse takes place when the ventricle strongly and completely empties itself; throwing out a great quantity of blood into the arteries, which fully distends them and stimulates them to a strong contraction. A pulse of this kind is common in strong healthy men, and is seldom to be accounted a symptom of disease. But if it be too strong, and strike the finger of the person who feels it violently and sharply, it is called a *hard pulse*. This hardness is produced by a sudden and violent contraction of the heart and arteries, which distends even the remote branches, as those of the wrist, too suddenly and

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and smartly, and excites them also to sudden and violent contractions.

A hard pulse therefore denotes too great an action of the heart and arteries. It may arise from various causes: in the first place, from too great a tension of the vessels; for instance, from their being too full, and by that means more prone to motion, and the more fit for receiving violent motions. It may arise also from too great a density and firmness of the solids; and hence it is most frequent in cold countries, among strong robust people and such as are accustomed to hard labour. It may likewise arise from various causes irritating the whole nervous system, or only the heart and arteries. Lastly, It accompanies many fevers, as well as most inflammatory disorders, whether the inflammation arises from a general stimulus applied to the whole body, or from the irritation of particular parts, by degrees extended over the whole body. In such a state of the circulation, the patient frequently stands in need of blood-letting, and almost always bears it well.

A small, weak, and soft pulse is generally owing to causes opposite to the former, and indicates a contrary state of the circulation and nervous system. It frequently requires stimulants; nor does it generally require blood-letting, or easily bear it. Sometimes, however, a pulse of this kind is observed even in the case of a dangerous inflammation, of the stomach for instance, or intestines. But in these and the like examples we ought to attend to the nature of the malady, much more than to the state of the pulse.

The pulse is said to intermit, when the stroke does not return after the usual interval, and perhaps not till after twice, thrice, or four times the usual space. A pulse of this kind seems to be almost natural and constant in some animals, and is common to some men even in the most perfect health; and if these happen to be seized with a fever, the pulse sometimes becomes regular, nor can the disease be removed before the intermission has returned.

Moreover, in some people, though their pulse beats equally while in health, yet the slightest illness makes it intermit; and in others, especially those who have a great deal of mobility in their constitution, such as hypochondriac and hysteric people, the intermission of the pulse is felt, without applying the finger to the artery, merely by the uneasiness which they perceive in their breasts during those intervals in which the pulse is deficient. An intermittent pulse likewise occurs in many diseases of the breast, especially when water is collected in it; and the like happens in the end of all diseases, especially fevers, when the strength is nearly exhausted, and death approaches, of which it is frequently the forerunner.

An intermitting pulse therefore seems to arise from an unequal influx of the nervous power into the heart, or from the decay and exhaustion of the nervous power, by which means the heart is not able to contract till it has been distended beyond its due pitch. Or, lastly, It may arise from diseases of the organ itself, or the neighbouring parts; from swellings, water, &c. pressing upon them, and impeding the action of the heart: which is indeed is a very dangerous disorder, and almost always mortal.

Many other variations of the pulse are enumerated by physicians, but most of them are uncertain, and not confirmed by experience. We shall therefore now consider the motion of the blood, which may be either too great, too small, or irregular.

A quick pulse, *cæteris paribus*, produces a more rapid circulation, because the sooner that the ventricle of the heart is emptied, the more quickly is the blood thrown into the arteries; and their actions must answer to this stronger stimulus. Hence exercise, heat, stimulants, plethora, every kind of irritation, passions of the mind, and fever, increase the circulation. The effect of this increase is a distention of the vessels, a stimulus applied to the whole body, an increase of heat, and often a debility. The secretion of sweat is increased while the other secretions are diminished, and the various functions of the body impeded; thirst comes on, the appetite is lost, the fat consumed, and a disposition to putrescency introduced. Sometimes the smaller vessels are burst; whence effusions of blood and hæmorrhages. But we are by no means to forget, that this violent motion of the blood, however hurtful it may seem, is among the best remedies made use of by nature in curing many diseases.

The motion of the blood is diminished, especially by debility, torpor, the want of irritation, or of exercise; the same thing happens to all the fluids, if there be any obstruction in the vessels, or any cause by which their return is hindered or rendered more difficult. Thus, from the very weight of the blood itself, if a person has stood long on his feet, the humours return more slowly from the inferior extremities. Any disease of the heart and arteries also, as an aneurism, contraction, ossification, must necessarily obstruct the circulation. The same thing happens from obstructions of the veins, or interrupted respiration, by which the passage of the blood through the lungs to the left side of the heart is impeded.

But, from whatever causes this diminution of the circulation takes place, the bad consequences are perceived chiefly in the veins, because in them the blood always moves more slowly than in the arteries. Hence varices, and congestions of blood, especially in those parts of the body where the veins are destitute of valves, and of consequence where the motion of the muscles cannot assist the circulation. Hence also arise dropsies from an impeded or languid motion of the blood; because the resistance of the veins being increased, the blood is received into them with the greater difficulty, and more of the thin humour is driven into the exhaling vessels, and by them deposited in such quantities as cannot be reabsorbed by the lymphatics. These diseases, as well as all others proceeding from defects of the circulation, are also more difficult of cure than others, because all the vital powers are weakened at the same time.

Another disorder of the circulation is where the blood is carried to one part of the body in too great quantity, by which means the other parts are deprived of their due proportion. This irregular distribution of the vital fluid frequently arises from a stimulus applied to the part itself, or to the brain, or at length acting on the mind, which, according to the laws of sympathy, produces a certain definite distribution of the

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the blood. It arises also not unfrequently from a spasm taking place in some other parts, which drives the blood out of its ordinary course.

In proportion to this irregularity of the circulation are the consequences; heat, swelling, redness, inflammation, rupture of vessels, hæmorrhages, effusions, destruction, corruption, and suppuration of the cellular texture and adjoining parts, &c. Even this evil, however, nature often converts into an excellent remedy; and physicians, following her steps, frequently attempt to direct the distribution of the blood in particular diseases, well knowing that a change in the distribution of the blood is frequently efficacious either for radically curing some diseases, or relieving their most urgent symptoms.

97 Palpitation.

Lastly, Some disorders in the motion of the heart itself, and those of no small consequence, remain yet to be taken notice of, namely, palpitation and syncope. A palpitation is a violent and irregular action of the heart, such as for the most part is perceived by the patient himself, and that not without a great deal of uneasiness and oppression at his breast; and it is also manifest to the by-standers, if they apply their hands, or look at his naked breast; the pulse of the arteries in the mean time being weak, unequal, and intermittent. This is a spasmodic disorder; and is induced by various causes affecting either the nervous system in general, or the heart in particular. Every disease of the organ itself, such as a constriction of its valves and blood-vessels, an ossification, enlargement, or polypus, hindering the free action of the heart, and evacuation of blood from it, are capable of exciting it to violent and unusual contractions. The same effect will also follow plethora, or too violent an impulse of the blood. The heart will likewise frequently palpitate from a violent excitement of the nervous system, especially where the constitution is endowed with a great deal of mobility. Hence palpitations arise from any affection of the mind, and in hysteric women. Palpitation may likewise arise from an affection of the stomach, occasioned by worms, a surfeit, flatus, or stimulation by various acrid substances. It frequently also accompanies the gout when repelled, or even when a fit is coming on. Sometimes it arises from debility, whatever may be the cause; frequently from any difficulty in breathing; and many of these causes may be joined at the same time, or some of them produce others.

Hence we may see why the evil is sometimes slight and of short continuance; at other times altogether incurable, and certainly mortal in a longer or shorter time; why it sometimes returns at intervals, often coming on and being increased by every kind of irritation and exercise, and sometimes relieved or totally removed by stimulants or exercise.

98 Syncope.

A syncope takes place when the action of the heart, and along with it that of the arteries, is suddenly and very much lessened; whence the animal powers, the senses, and voluntary motions, immediately cease. This may be produced by almost all the causes of palpitation; because whatever can disturb and disorder the motion of the heart, may also weaken or suspend it. The vitiated structure of the heart itself therefore, violent passions of the mind, whether of the depressing kind, or those which suddenly and vehemently excite, various kinds of nervous diseases, those of the stomach, every kind of debility and evacuation, especially a great loss of blood, excessive and unremitting labour, long watching, heat, pain, many kinds of poisons, &c. produce fainting.

Hence we see, that whatever weakens the motion of the blood through the brain tends to produce fainting; and, on the contrary, whatever tends to augment that motion, also tends to refresh, and to prevent the person from fainting. Hence also we see how the mere posture of the body may either bring on or keep off fainting, or remove it after it has already come on. We likewise see how this disorder may sometimes be of little consequence and easily removed; at others very dangerous, not only as a symptom, but even of itself, as sometimes terminating in death; and lastly, how it may be used as a remedy by a skilful physician, and artificially induced, either to free the patient from violent pain, or to stop an immoderate effusion of blood scarce to be restrained by any other method.

99 Buff-coloured c[rust] on the blood.

With regard to the disorders of the blood itself, the glutinous part of it, or, more properly, its fibrine separated from the red particles, produces that buff-coloured appearance often seen upon blood drawn from people afflicted with inflammatory disorders, and even sometimes when no such diseases are present. This crust indeed is nothing else than the fibrine of the blood taking longer time than usual to coagulate, by which means the red particles have an opportunity of falling to the bottom. This indicates no lentor, density, thickness, or tenacity of the blood, as was formerly thought; but rather its thinness, or at least a less tendency in it to coagulate. It arises for the most part from a violent agitation and conquassation of the blood within the body; and hence it accompanies many fevers, all inflammations, sometimes hæmorrhages, exanthemata, plethora, pain, and many irritations. It must, however, be allowed that in several of these diseases it is rendered highly probable at least, from experiments apparently accurate, that the quantity of the fibrine of the blood is really increased in the proportion which it bears to the other parts. This crust, however, is not always to be accounted morbid, as it often happens to the most healthy; and may even be produced or destroyed by the slightest causes while the blood is running from the vein, so that frequently we shall see a very thick and tenacious crust on the blood flowing into one cup, while that which runs into another has little or none at all. In general, however, the appearance of this crust shows, that the patient will bear blood-letting well, though those have been in a great mistake who have directed this operation to be repeated till no more crust appeared on the blood.

The coagulable part of the blood also frequently produces those masses called *polypi*, which sometimes take place during life, but more frequently after death, in the large vessels near the heart, or even in the cavities of that organ. Similar masses also are frequently formed in the uterus, and are called *moles*.

10[0] Pleth[ora].

The quantity of blood contained in a healthy body is very various, and difficult to be ascertained. Many diseases, however, may arise from its being either too scanty or too abundant. Too great a quantity of blood is produced by the use of rich, nourishing diet, strong drink, accompanied with a good digestion; from a lazy, sedentary life, or much sleep, especially in

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in those who have been formerly accustomed to much exercise; with many other causes of the same kind. It renders the person dull and languid, and sometimes almost totally oppresses him; nor are those organs destined for moving the blood sufficient for driving forward such a load. The pulse sinks; and sometimes a syncope, vertigo, or palpitation takes place. More frequently, however, the vessels are too much distended, and ready to be thrown into violent and irregular motions. Hence a disposition to fevers, inflammations, an unequal distribution of the blood, unusual congestions, rupture of the vessels, and hæmorrhages. Besides this, in consequence of the close connection between the sanguiferous and the nervous system, a fulness of blood produces a disposition to spasm and other diseases of that kind.

Hence we may understand why a plethora is sometimes accompanied with a weak and sometimes with a strong and hard pulse, why it is the cause as well as a part of so many distempers, why it is the effect of a high state of health, &c.

[1]01 [Defect] or Inanition.

The want of a due quantity of blood is no less pernicious than too great an abundance of it. It debilitates the person, and renders him unable to perform the proper duties of life; produces a languid circulation, syncope, spasms, and at last death itself. In a slighter degree of the disease the body is emaciated through want of nourishment, and its functions are vitiated in various ways. It may arise from want, bad food, or such as affords little nourishment: from bad digestion, or the chyle being hindered from passing into the blood: from fevers, or other diseases which exhaust the body and hinder nutrition: or lastly, from various evacuations, particularly of blood; and that the more especially if they are sudden, for in slow evacuations the vessels accommodate themselves surprisingly to the quantity left in them. Besides, if the body be slowly exhausted, the excretions are lessened by reason of the deficiency of the vital power; so that the unusual expence is easily compensated by the unusual retention. But if the evacuation happens to be very sudden and great, it may either prove mortal in a short time, or break the constitution to a degree beyond recovery.

[1]02 Morbid thinness of the blood.

By a great and long-continued deficiency of blood the quality of it also is impaired; because the thin part of it is easily and soon made up; but the glutinous, and red part, not so easily. Hence the blood becomes thin, pale, scarcely capable of coagulation, or of affording a proper support to the body. Too great thinness of the blood also proceeds from using much drink, especially of the aqueous kind, slender and unnutritious diet, a bad digestion in the stomach; from diseases of the lungs and those organs which elaborate the red part; or from suppression of the usual evacuations of thin humours, as sweat or urine, induced by cold, a fault of the secreting organs, or from putrescency. But along with this, other disorders of the blood concur.

A too thin and watery blood makes the face pale, the body weak and languid. The solid parts become flaccid from want of nourishment, and having too great a quantity of water in their composition. It brings on hydropic effusions of water in all parts of the body, by reason of the increased exhalation of that thin fluid which moistens all the inward parts; partly by reason of the vessels being relaxed beyond their usual pitch, and not making a proper resistance. Besides, in this case, the lymphatics are so far from absorbing more than usual, that, partaking likewise of the general debility, they are scarcely fitted for performing their proper offices.

Nature, however, has taken care, by the most simple means, to provide against so many and so great evils; for neither does the blood so easily become thin as some have imagined, nor when this quality takes place does it want a proper remedy. For almost instantly, if the person be otherwise in health, the excretions of watery matters are greatly augmented, and the whole mass of blood in a short time becomes as thick as formerly.

103 Morbid thickness of the blood.

The opposite to this, namely, too great a thickness of the blood, though often spoken of by physicians, is very rarely if ever observed; and those fevers and inflammations which have been thought to arise from thence, are now found to originate from other causes. The following would seem to be the law of the human constitution. As soon as the blood has attained the due degree of thickness, or gone in the least beyond it, the excretions are either suppressed or diminished, the body attracts more moisture from the air, the person is thirsty, and drinks as much as is necessary for diluting the blood. But if water be wanting, and the person cannot satisfy his thirst, then the blood is so far from being thickened, that by reason of a putrescency begun or augmented, it is much dissolved, becomes acrid, and is with difficulty contained in the vessels.

104 Acrimony of the blood.

The acrimony of the fluids has afforded a large field for declamation to speculative physicians, and upon this slender foundation many perplexed and intricate theories have been built. It is certain indeed, that the blood in a state of health has some small share of acrimony; and this acrimony, from certain causes, may be a little increased so as to produce various diseases of a dangerous nature. This we are assured of from the increase of motion in the heart and arteries, and the similar augmentation of the action of the secretory organs, when certain acrid substances are taken inwardly. The same thing also appears from the unusual acrimony of the secreted fluids in such cases, by which the vessels are sometimes greatly stimulated, and sometimes even quite eroded. Very many acrid substances, however, are daily taken into the stomach; so that these must either be corrected in the *primæ viæ*, or changed by digestion before they pass into the blood; or at least by dilution with much water, or being blunted by an admixture with gluten, oil, or different gases, they must deposit much of their acrimony, and at last be thrown out of the body as noxious substances. Thus a vast quantity of salts, acid, alkaline, and neutral, may pass through the body, without in the least affecting the health; though these salts, if taken in very large quantity, undiluted, or not thrown out of the body, will do much hurt.

Moreover, even while life continues, putrefaction is going on, and produces much of that substance called *animal* salt; for into this a great part of our food is converted, and passes off by urine. But if this putrescent disposition be too great, it will produce too large a quantity of animal salt; especially if much of any saline substance is otherwise thrown into the body without

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without proper dilution: and this kind of disease is well known to sailors who have been long at sea, without having an opportunity of getting fresh provisions.

For this spontaneous putrescency, nature has suggested a proper remedy, namely, fresh meat, especially of the vegetable and acescent kind, and such as is much impregnated with acid, which it may impart to the body. But where this kind of food is wanting, the putrefaction goes on apace, and a very great thinness and acrimony of the juices take place; especially if there be also a scarcity of urine, or the excretions which ought to carry the putrid matters out of the body languish, either from cold, sloth, torpor, depressing passions of the mind, or from the constitution being broken by diseases; or, lastly, from too great heat, which always favours putrefaction.

Besides, it would seem, that sometimes a disposition to putrefaction is much increased by the reception of a putrid ferment into the body; of which we have examples in some infectious fevers, where the contagion is very much assisted by heat, animal diet, certain kinds of salts, debility and nastiness.

Lastly, Any single part of the body may putrefy from various causes, as from inflammation, cold, &c. and thus may the whole body be infected; although for the most part the disease proves fatal before the corruption has spread over the whole body.

But when the mass of blood begins to putrefy greatly, it not only becomes very acrid, but thin, also, so that it either will not coagulate at all, or shows only a slight and very loose crassamentum. Nay, even the red globules are broken down and destroyed; in which case it necessarily follows, that the blood must become very acrid, as well on account of the evolution of the salt, as by reason of the rancid and putrid gluten, which stimulates, and frequently even erodes, the vessels; producing spots, first red, then livid and black, tumours, and ulcers scarce possible to be cured, without first removing the putrescent disposition of the humours. From the same causes proceed hæmorrhages from every part of the body, hardly to be restrained; a most intolerable fetor of the breath and all the excrements; the highest debility and laxity of the solids; the putrefaction acting as a poison to the nervous system, and at length bringing on death.

An acrimony of the acid kind never takes place in the human blood, nor in any of the humours secreted from it; though one of them, namely the milk, turns acid spontaneously in a very short time after it is drawn from the breast. Neither does an alkaline acrimony seem ever to take place in the blood. Putrescency indeed tends this way, and at last terminates in it; but scarcely while the person lives, though the nature of the urine, even while recent, seems to be but little distant from that of an alkali.

Many kinds of acrimony may exist in the blood from too liberal an use of spices, wine, spirits, &c. but of these we know nothing certain. We well know, however, that the body is often infected with various kinds of morbid acrimony, which bring on many and dangerous diseases, as the small-pox, measles, cancers, lues venerea, &c. of which the origin and manner of acting are very little understood, though the effects are abundantly evident. In most cases, nature has taken no less care to provide against the *acrimony* than against the too great *viscidity* of the blood. Sometimes an antidote is afforded, either by the excitement of thirst, that the acrid substance may be diluted with plenty of drink; or by increasing the evacuations, that it may be thrown out of the body; or lastly, by exciting various motions and actions of the vital powers, by which it may be either subdued, changed, rendered innocent, or expelled from the body by new and unwonted passages.

Disorders of Respiration.

105 Respiration.

With regard to respiration, it may be obstructed from various causes seated either in the lungs themselves or the surrounding parts. But from whatever cause this obstruction may arise, it undoubtedly produces all those diseases which proceed from an interrupted circulation. The lungs themselves also being at length compressed, and not suffered to dilate sufficiently, cannot throw off the vapour which arises from them; and hence they are frequently oppressed with moisture. At the same time they are irritated, so that a greater quantity of mucus, and that of a thicker kind than usual, is secreted; by which means the passages through which the air enters them are stopped up, till a violent cough at length throws off the load.

The respiration is also subjected to some other disorders, as a cough and sneezing, which, though at first sight they may seem very dangerous, are not destitute of use, and may even be reckoned among the most salutary attempts of nature to relieve the patient. Often, however, they are attended with danger, or very great uneasiness; namely, when they are either too violent or exerted in vain. At any rate, it is necessary for a physician to know the nature, causes, and effects of these, that he may be enabled to promote them when necessary, to moderate them when too violent, and to stop them when noxious or of no use.

10 Cough.

A cough is a violent, frequently involuntary, and sonorous exspiration, suddenly expelling the air with great force through the glottis somewhat contracted. The convulsion of the muscles serving for exspiration, gives a great force to the air, while the contraction of the glottis produces the sound. It is often long continued, being repeated at certain intervals, during each of which the inspiration is imperfect and obstructed by reason of the contraction of the glottis. It is excited by any kind of acrid substance, either chemically or mechanically applied to those passages through which the air enters. These are lined with a membrane so exceedingly delicate and impatient of stimulus, that it cannot even bear the touch of the mildest substance, such as a small drop of water, without throwing the muscles serving for exspiration into a violent convulsion; the glottis at the same time contracting by means of the sympathy between it and the neighbouring parts. Thus the air is thrown out with such violence, that it drives the irritating substance along with it; and thus a cough becomes not only useful, but absolutely necessary for the preservation of life, as being able to free the lungs from every kind of irritating substance or foulness, which might soon bring on a suffocation. Hence a cough is almost an inseparable companion of every inflammation of the lungs, as well as every difficulty in respiration; and even frequently accompanies the entrance of the purest air when the

trachea

Disorders of Respiration.

trachea and bronchiæ are excoriated, or become too sensible. Examples also are not wanting, where a violent and troublesome cough has arisen from an irritability of the nervous system, or even of some particular part, of the ear, for instance, the stomach and intestines, the liver by inflammation, &c.

Coughing may also be voluntarily excited, and may then be managed at pleasure. Even when involuntary, it may be moderated, or suppressed, by a contrary effort: though a violent fit of coughing cannot by any means be resisted. When it is once excited, the cough goes on till the irritating substance be expelled, or the sense of irritation abolished, or perhaps overcome by a more uneasy sensation than even the cough itself; after which the irritation again returning at a certain interval, the cough also returns. Hence we are taught a method of allaying and quieting this most troublesome malady, though frequently it is not in our power to remove the cause of it altogether.

A very violent cough is often dangerous: For by the retention of the breath, and the strong efforts made in coughing, a great quantity of blood is collected in the lungs, of which the vessels are distended, and frequently broken; and hence there sometimes happens a violent and even fatal hæmorrhage. More frequently, however, it is the cause of a slower, though equally fatal, disease. Nay, a frequent and troublesome cough, without any great hæmorrhage, or even without any hæmorrhage at all, may injure the lungs to such a degree, especially if they be of a more tender structure than usual, as to lay the foundation of a phthisis almost always incurable.

Again, by a long-continued and violent cough, the passage of the blood through the lungs being impeded, it must necessarily flow through the veins towards the head: hence redness and lividness in the countenance, hæmorrhages, palsies, apoplexies, and sometimes fatal convulsions. Lastly, by a violent cough the abdominal viscera are compressed with remarkable violence; and if any part happens to be weaker than usual, a hernia, prolapsus uteri, abortion, or similar accidents, may happen.

Even when the cough is more gentle, if it happens to be importunate and frequent, although we have nothing of this kind to fear, yet the patient is by no means free from danger; as he is thereby agitated, fatigued, has his constitution broken, is deprived of rest, has a fever brought upon him, his lungs are shaken and irritated, digestion and all the other functions are impeded, till at last he sinks under a complication of maladies.

107 Sneezing.

Sneezing is somewhat similar to cough, as consisting of a very full inspiration, to which succeeds a most violent exspiration, by which the air is driven out through the nostrils with immense violence, and sweeps the passage through them as it goes out. It is a convulsion much more violent than a cough, and is besides very difficult to be stopped when once a propensity to it has taken place. As a cough proceeds from an irritation of the glottis, trachea, bronchia, and lungs, so sneezing arises from an irritation of the membrane of the nostrils, but rarely from sympathy with any distant part. It is sometimes of service, as well as a cough; though it is also sometimes prejudicial, for the reasons which have been already assigned.

Disorders of Digestion.

The last affections of which we shall here speak, are those arising from a bad digestion, disordered motion of the intestines, and some of the principal secretions. The first of these are sometimes very troublesome, though seldom dangerous. The principal symptoms are oppression, anxiety, pain at the stomach; eructations, by reason of air extricated from the fermenting aliments, and irritating the stomach; nausea and vomiting, from the irritation and distention of the same organ; the belly sometimes too costive, and sometimes too loose; a defect of nourishment; a general debility; relaxation of the solid parts; too great thinness of the fluids; all the functions impeded; pain of the head; vertigo, syncope, asthma, palpitation; great sinking of the spirits, especially if the patient has been of a peculiar constitution; sometimes the gout, sometimes a dropsy, or a slow fever which may prove fatal. 108 Digestion.

109 Costiveness.

The motion of the intestines may be either too great or too little; and hence proceeds either costiveness or looseness. The former is frequently not to be accounted morbid; but, when it is, it may arise from the structure of the intestines being injured, or from their being shut up or obstructed by spasm or otherwise, or from a deficiency of those humours which moisten the intestines; or, it may arise from mere debility, from a palsy of the fibres, perhaps, or from a deficiency of the usual stimulus, of the bile, for instance, or from too dry or slender a diet.

The consequences of long-continued costiveness, are, first, an affection of the alimentary canal, and then of the whole body. The stomach is diseased, and does not digest the aliments properly; the whole body is left destitute of its usual stimulus; the blood is corrupted, perhaps from the resorption of the putrid matter into it. The circulation through the abdominal viscera is impeded; hence frequent and irregular congestions, varices of the veins, hæmorrhoids, &c. Nay, the intestines themselves being overloaded, distended and irritated by an heavy, acrid, and putrid load of aliment or other matters, are excited to new and unusual contractions, which, if they do not get the better of the obstruction, bring on tormina, colic, or an iliac passion, inflammation and gangrene, fatal in a very short time.

110 Looseness.

Looseness, or diarrhœa, is a malady extremely common; being sometimes a primary disease, and sometimes only a symptom or an effect of others. Sometimes it is a salutary effort of nature, such as the physician ought to imitate and bring on by art. It is also familiar to infants, and to people of a certain constitution; and to them costiveness is very prejudicial. It may arise, in the first place, from something taken into the body, or generated in the intestines; from a fermentation and corruption of the mass of aliments; from the bile being too abundant and acrid, or from blood or pus poured into the intestines; from the intestines themselves being eroded, or deprived of their natural mucus; from the humours being driven from the surface of the body towards the inward parts, as by cold, especially when applied to the feet; or from a general corruption of the whole body, as in the phthisis, hectic, or putrid fever, especially towards the end of these disorders. In fevers it is sometimes salutary, or even puts an end to the disease altogether, or at

Disorders of the Alimentary Canal.

at least renders it milder; more frequently, however, deriving its origin from putrescency, it is of no service, but rather exhausts the strength of the patient. A diarrhœa likewise, almost incurable, and often fatal in a short time, frequently arises after the operation for the fistula in ano. Some have their intestines so extremely weak and moveable, that from the slightest cause, such as catching cold, any violent commotion of the mind, &c. they are subject to a violent diarrhœa. Lastly, whatever be its origin, if it has continued for a long time, the viscera are rendered so weak and irritable, that the disease, though often removed, still returns from the slightest causes, and even such as are not easily discovered.

A diarrhœa proves very pernicious, by hindering digestion and the nourishment of the body; for the stomach is commonly affected, and the aliments pass through the intestines so quickly, that they can neither be properly digested, nor are the lacteals able to absorb the chyle from them as they go along. Such a violent evacuation is also hurtful by exhausting the body, and carrying off a great quantity of the nutritious matter from the blood. Neither indeed, is it only the alimentary mass which is thrown out sooner than it ought to be; but at the same time, a great quantity of the fluids secreted in the intestines, so that the whole body quickly partakes of the debility.

Sometimes a violent and long-continued diarrhœa rises to such a height, that the aliment is discharged with little or no alteration. Sometimes also, though rarely, from a similar cause, or from the obstruction of the mesenteric glands, and its other passages into the blood, the chyle itself is thrown out like milk along with the excrements; and this disease is called
111 the *fluxus cœliacus*.

Dysentery.

A dysentery is attended with very severe gripes in the belly, a frequent desire of going to stool, and vain efforts, when nothing is excreted besides the mucus of the intestines mixed with a little blood; it is also accompanied with excessive debility, and frequently with putrescency and fever. It is thought to arise from the constriction of some part of the intestines, of the colon especially: by which means the bowels, though ever so much irritated, can pass nothing; neither can the disease be removed, until the belly has been well
112 purged by proper medicines.

Tenesmus.

A tenesmus is a frequent and insatiable propensity to stool, without being able to pass any thing, notwithstanding the most violent efforts. It may be occasioned by any kind of irritation, either of the rectum itself or of the neighbouring parts, by acrid substances taken into the body; by some of the stronger purges, especially aloes, a substance very difficult of solution, which will pass even to the rectum with very little alteration; by a violent and obstinate diarrhœa, dysentery, hæmorrhoids, worms, fistula, calculus, ulcer in the bladder, urethra, &c. It is often very pernicious, both from the excessive uneasiness it occasions to the patient, and from its exhausting his strength, by the frequent and vain efforts bringing on a prolapsus ani, and communicating the violent irritation to the neigh-
113 bouring parts, as the bladder, &c.

Nausea and vomiting.

A nausea and vomiting are disorders very common, and owing to almost innumerable causes; not only to affections of the stomach itself, but also to affections and irritations of the remotest parts of the body which may act upon the stomach by sympathy. Every irritation and distention of that viscus therefore, a load of crude aliment, an obstruction about the pylorus, all acrid substances taken into it, diseases of the liver, intestines, kidneys, uterus, the head, the feet, the skin, or indeed the whole body, inflammation, the stone, king's evil, schirrus, apoplexy, compression of the brain, fracture of the skull, vertigo, syncope, violent pain, the gout, especially when repelled, fevers, passions of the mind, disagreeable imaginations or discourses, frequently induce nausea and vomiting.

These affections are often serviceable by freeing the stomach from something with which it was overloaded; promoting spitting in some cases where the lungs are overcharged with mucus, blood, pus, or water; producing sweat, and a free and proper distribution of blood to the surface of the body; partly, perhaps, by the great straining which accompanies vomiting, but rather by that wonderful sympathy which takes place between the stomach and skin: and hence, in many diseases, vomiting is a most excellent remedy. It is however in some cases hurtful, if too violent or too frequently repeated, partly by debilitating and making the stomach more easily moved; and partly by fatiguing the patient with violent strainings, which occasion hernias, abortions, &c. 11

Iliac passion.

Sometimes we find the motion of the intestines totally inverted, from the anus to the mouth; a most dangerous distemper, which hath obtained the name of the *iliac passion*. It most frequently arises from some obstruction in the alimentary canal hindering the descent of the excrements, as schirrus, spasm, inflammation, &c.: though the most perfect iliac passion takes place without any obstruction, so that clysters will be vomited; and even after this has continued for several days, the patients have at length recovered.

A slighter degree of the iliac passion, namely the inversion of the peristaltic motion of the duodenum, always takes place in long-continued and violent vomiting, as in sea-sickness, or when a person has taken too large a dose of an emetic; by which means a vast quantity of bile frequently ascends into the stomach, and is discharged by vomiting. 1

Chol

An excessive vomiting with looseness is called a *cholera*, when the matter discharged has a bilious appearance. It arises from a very great irritation of the alimentary canal without any obstruction; and is for the most part occasioned by too great a quantity, or from an acrimony of the bile, from whence it takes its name. It may originate from several causes, as too strong a dose of an emetic and cathartic medicine, eating too great a quantity of summer-fruits, &c. and is a very violent malady, often killing the patient in a few hours, unless proper remedies be applied in time.

Obstructed perspiration.

From a suppression of any of the secretions, or a disorder of any of the secretory organs, many mischiefs may arise. A diminution of perspiration produces plethora, lassitude, languor, depression of mind, bad digestion, loss of appetite, and even a general corruption of the humours from the retention of such a quantity of putrescent matter.—The more suddenly the diminution or suppression of the perspiration takes place, Di ders of ere- t i. place, the sooner the mischief is produced, and the greater it is; not only by retaining the matter which ought to be thrown out, but by repelling the humours from the surface of the body, and directing them to other parts; whence fevers, inflammations, congestions of the blood, &c. frequently take place.

This suppression of perspiration may arise from many different causes; as from cold suddenly applied to the body when very hot: sometimes from very violent passions of the mind; or from spasmodic diseases, as the hysterics, &c. It may be suppressed also by that kind of constriction of the vessels of the skin which is produced by various kinds of fevers, the nature of which has hitherto been but little known.

7 Ex sive per a- tion Excessive perspiration or sweating is injurious by debilitating the body, relaxing the skin, and exposing the patient to all the evils which arise from catching cold. It may even be carried to such a height as to produce fainting and death; though it must be owned that we cannot easily bring examples of people having, from this cause, their blood inspissated, corrupted, or being thence made liable to inflammations and fevers.

8 Su ession of u e. A suppression of urine is still more dangerous than that of perspiration, and unless relieved in a short time will certainly prove fatal. This disorder, which is called *ischuria*, may arise from various diseases of the kidneys, ureters, bladder, urethra, &c. Thus any obstruction or irritation of one or other of the kidneys or ureters, by a stone, gravel, mucus, blood, inflammations, spasm, suppuration, schirrus, swellings of the neighbouring parts, &c. may either prevent the urine from being secreted, or may give rise to a scanty or depraved secretion, or, finally, may obstruct its passage into the bladder after it is secreted.

The urine also, after it has entered the bladder, is there frequently suppressed, by reason of various disorders to which that organ is liable, as an irritation or inflammation, spasm, acrid substances injected, or sympathy with the neighbouring parts; or by reason of the texture of the bladder itself being destroyed, or from a palsy, schirrus, ulcer, &c. in the bladder. Or, lastly, the urine may be retained in the bladder from a general stupor, as from a disease of the brain, which happens in some fevers, when the patient is neither sensible of the usual stimulus, nor even of one much greater, so that the fibres can scarcely be excited to contraction by any means whatever. This, in fevers, is always a bad sign, and sometimes even proves fatal.

A suppression of urine for any length of time produces an immense distention of the bladder, oppression, uneasiness, and pain, not only of the part itself, but of the surrounding ones, and even of the whole body; a spasm, or insuperable constriction of the sphincter; an inflammation, gangrene, or laceration of the bladder itself; a violent irritation of the whole habit; then a nausea, vomiting, vertigo, general stupor, and an impregnation of the whole mass of blood with a humour of an urinous nature, which at last being poured out into various cavities of the body, especially of the head, soon brings on a deep sleep, convulsions, and death.

9 Dy a. From the same causes, but acting with less force, proceeds that disease called a *dysuria*, when the urine passes with difficulty and pain, and is frequently red, black, bloody, purulent, mucous, and sandy; the reason of all which appearances is very much unknown.—The most frequent complaint, however, in making water, is where the patient has a continual and violent desire of passing his urine, while at the same time only two or three drops can be passed at once, and that not without some pain. This may be occasioned even in healthy people, by some acrid substance taken into the stomach; and is very common to old people, who are generally subject to disorders of the kidneys and bladder. It arises also frequently from a stone irritating the bladder, or from an inflammation of it, or of its being deprived of its mucus, or this last being somehow or other corrupted; or lastly, from certain diseases, or some particular state of the neighbouring parts, as of the uterus, vagina, urethra, prostate gland, &c. Disorders of Secretion. 120 Strangury.

Akin to the strangury is an incontinence of urine, when the patient's water either comes away against his will, or altogether without his knowledge. This disorder may arise from debility, palsy, an ulcer or wound, or any long-continued and violent irritation of the bladder, especially of its sphincter, as from a stone, a general palsy, or in females difficult labour, injuring the neighbouring parts.—This symptom occurs in a great number of diseases, especially in the hydrocephalus.—Sometimes the urine is expelled with violence, either by reason of universal spasms, or by violent contractions of the muscles of respiration, as in sneezing, laughter, &c. 121 Incontinence of urine.

Among the disorders incident to the urine we may reckon the production of calculi, which frequently bring on the most excruciating and dangerous diseases.—The urine, besides the water and salts, contains no small share of the glutinous part of the blood already somewhat corrupted, and still inclined to farther corruption. Hence the urine even of the most healthy people deposits a sediment after it has stood for some time; and though none of this sediment be formed in a healthy body, yet if the smallest particle of foreign matter be introduced into the bladder, a crust soon gathers round it, and it is sure to become the basis of a concretion, which by degrees grows to a very great size. It is not unlikely, also, that some unknown faults of the fluids may contribute to the production of those calculi, as the stone is well known to be an hereditary disease, and to be born with the patient. Calculous persons also are commonly subject to complaints of the stomach, especially to an acidity of it; and many have received no little relief from alkalescent or alkaline medicines.—From the same causes may calculi be formed in the kidneys; from which proceed a horrid train of symptoms described in the subsequent part of this treatise. 122 Urinary calculi.

It is now found, by accurate experiments of the most able chemists, that urinary calculi do not, as was once supposed, consist almost entirely of an earthy matter. Their principal constituent is a peculiar acid, approaching more nearly to the phosphoric found in the bones than to any other. But the acid of calculus being in some respects peculiar in its nature, has among modern chemists obtained a peculiar name, and been distinguished by the appellation of the *lithic* or *uric acid*. It is highly probable that this acid present in the circulating mass, is precipitated and disengaged by the

Disorder of the Glands. introduction of other acids, and thus thrown off in greater quantities by the kidneys. Thus, then, we can understand the influence of acids as tending to the generation of calculus, and of alkalies as tending to prevent it.

123 Schirrus. The last disorder here to be taken notice of is a disorder of the glands themselves, owing to some kind of obstruction, and is one of the most dreadful diseases incident to human nature. Hence happens a great swelling and surprising hardness, not only without pain, but sometimes even with a diminution of sensation in the part affected; and when the gland is thus affected, it is called a *schirrus*. Sometimes it remains in this state for a long time; but sooner or later produces the most excruciating torment. By degrees it is infected with a slow and malignant suppuration, degenerating into an horrid ulcer, consuming not only the part itself, but eating away the neighbouring ones, and corrupting the whole body with the most acrid and incurable poison. This disease is called a *cancer*, of which the causes are very little known.

Versatility of the Human Constitution. Of the organs in both sexes concerned in the function of generation, and of that function as far as we yet know any thing respecting it, an account has already been given in ANATOMY; and after what has been said of the different functions, and of the morbid affections, to which these are subjected, we may conclude our remarks on the theory of medicine, with mentioning the remarkable versatility of the human constitution; which more than that of any other animal, is capable of accommodating itself to every climate and to all kinds of diet. Hence we may conclude, that a large proportion of the diseases to which we are subjected are produced by ourselves.

PRACTICE of MEDICINE, or an Account of the principal Diseases to which the Human Body is subjected.

124 General arrangement of diseases. WE have already defined medicine to be the art of preventing, curing, and alleviating, those diseases to which mankind are subjected. While these affections, however, are in number almost infinite, each in its progress is subjected to almost endless varieties from differences in climate, constitution, treatment, and a variety of other particulars. Hence we may readily explain both the difficulty of distinguishing morbid affections from each other in actual practice, and the diversity of names which have been affixed to them in the writings of ancient physicians. It may readily be supposed, that in this, as well as other subjects, there has been a gradual improvement from the progressive labours of industrious and ingenious men. And although much yet remains to be done in the proper arrangement and distinction of diseases, or what has been called *methodical nosology*, yet there cannot be a doubt, that during the course of the 18th century, this subject has received very great improvements. For these, we are, in the first place, highly indebted to the labours of Franciscus Boissier de Sauvages, an eminent professor of medicine at Montpelier, who, following out an idea suggested by the sagacious Dr Sydenham of England, first successfully attempted to arrange diseases, as botanists had done plants, into classes, orders, genera, and species. Since the publication of the *Nosologia Methodica* of Sauvages, this subject has been successfully cultivated by several ingenious men, particularly by Sir Charles Linnæus of Upsal, to whose genius for arrangement every branch of natural history, but botany in particular, has been so highly indebted; by Rudolphus Augustus Vogel, an eminent professor at Gottingen; and by John Baptist Sagar, a distinguished physician at Iglaw in Moravia: But of all the systems of arrangement yet presented to the medical world, that published by the late illustrious Dr William Cullen of Edinburgh, may justly be considered as the best. In treating, therefore, of the principal diseases to which the human body is subjected, we shall follow his plan, endeavouring to deliver the best established observations respecting the history, theory, and practice of each. In treating of particular genera of disease, although we follow the arrangement of Dr Cullen, yet for the satisfaction of the reader, we shall often point out the classes to which the same affection is referred by the other eminent writers whom we have mentioned. And on this account, it may not be improper briefly to enumerate the general classes to which each of them have referred the affections of the human body.

The Classes of Sauvages are,

1. Vitia.	6. Debilitates.
2. Febres.	7. Dolores.
3. Phlegmasiæ.	8. Vesaniæ.
4. Spasmi.	9. Fluxus.
5. Anhelationes.	10. Cachexiæ.

The Classes of Linnæus are,

1. Exanthematici.	7. Motorii.
2. Critici.	8. Suppressorii.
3. Phlogistici.	9. Evacuatorii.
4. Dolorosi.	10. Deformes.
5. Mentales.	11. Vitia.
6. Quietales.	

The Classes of Vogel are,

1. Febres.	7. Hyperæstheses.
2. Profluvia.	8. Cachexiæ.
3. Epischeses.	9. Paranoiæ.
4. Dolores.	10. Vitia.
5. Spasmi.	11. Deformitates.
6. Adynamiæ.	

The Classes of Sagar are,

1. Vitia.	8. Anhelationes.
2. Palgæ.	9. Debilitates.
3. Cachexiæ.	10. Exanthemata.
4. Dolores.	11. Phlegmasiæ.
5. Fluxus.	12. Febres.
6. Suppressiones.	13. Vesauiæ.
7. Spasmi.	

Besides

General Arrangement of Diseases.

Besides these, two other systems have been presented to the public, which may be considered as deserving attention; those, viz. of the late learned Dr M'Bride of Dublin, and of the late ingenious Dr Darwin.

The Classes and Orders of M'Bride.

Class. I. *Universal Diseases.*

Or. 1. Fevers.
2. Inflammations.
3. Fluxes.
4. Painful diseases.
5. Spasmodic diseases.
6. Weaknesses or privation.
7. Asthmatic disorders.
8. Mental disorders.

Class II. *Local Diseases.*

Or. 1. Of the internal senses.
2. Of the external senses.
3. Of the appetites.
4. Of the secretions and excretions.
5. Impeding different actions.
6. Of the external habit.
7. Dislocations.
8. Solutions of continuity.

Class III. *Sexual Diseases.*

Or. 1. General proper to men.
2. Local proper to men.
3. General proper to women.
4. Local proper to women.

Class IV. *Infantile Diseases.*

Or. 1. General.
2. Local.

The Classes and Orders of Darwin.

Class I. *Diseases of Irritation.*

Or. 1. Increased irritation.
2. Decreased irritation.
3. Retrograde irritative motions.

Class II. *Diseases of Sensation.*

Or. 1. Increased sensation.
2. Decreased sensation.
3. Retrograde sensitive motions.

Class III. *Diseases of Volition.*

Or. 1. Increased volition.
2. Decreased volition.

Class IV. *Diseases of Association.*

Or. 1. Increased associated motions.
2. Decreased associated motions.
3. Retrograde associated motions.

After this short view of different classifications, we shall next present to our readers a more particular account of the arrangement of Dr Cullen; which, although it can by no means be represented as free from errors or imperfections, is yet in many respects the best that has hitherto been published.

Cullen's *Arrangement.*

Class I. PYREXIÆ. A frequent pulse coming on after a horror; considerable heat; many of the functions injured; the strength of the limbs especially diminished.

Order I. Febres. Pyrexia without any primary local affection, following languor, lassitude, and other symptoms of debility.

Sect. I. *Intermittentes.* Fevers arising from the miasma of marshes; with an apyrexia, or at least a very evident remission; but the disease returns regularly, and for the most part with a horror or trembling.

Genus I. Tertiana. Similar paroxysms after an interval of about 48 hours, coming on most commonly at mid-day. A tertian hath either;

I. An apyrexia interposed.

1. Varying in the duration of the paroxysms.

A, The tertian whose paroxysms are not extended beyond 12 hours.

B, The tertian with paroxysms extended beyond 12 hours.

2. Varying in the return of paroxysms.

C, The tertian returning every day with unequal paroxysms alternately similar to one another.

D, The tertian returning every third day with two paroxysms on the same day.

E, The tertian returning every day, with two paroxysms on every third day, and only one on the intermediate ones.

F, The tertian returning every day, with an evident remission interposed between the odd and the even days, but a less remarkable one between the even and the odd days.

3. Varying in its symptoms.

G, The tertian accompanied with a disposition to sleep.

H, Accompanied with spasms and convulsive motions.

I, Accompanied with an efflorescence on the skin.

K, With phlegmasia.

4. Varying in being complicated with other diseases.

5. Varying as to its origin.

II. With the interposition only of a remission between the paroxysms.

Genus II. Quartana. Similar paroxysms, with an interval of about 72 hours, coming on in the afternoon.

I, With the interposition of an apyrexia.

1. Varying in the type.

A, The quartan with single paroxysms, returning every fourth day, none on the other days.

B, With two paroxysms every fourth day, and none on the other days.

C, With three paroxysms every fourth day, and none on the intermediate days.

D, Of the four days having only the third free from fever, with similar paroxysms every fourth day.

E, The quartan coming on every day, with similar paroxysms every fourth day.

2. Varying in its symptoms.

3. Varying in being complicated with other diseases.

II. With a remission only between the paroxysms.

Genus III. Quotidiana. Similar paroxysms with an

General Arrangement of Diseases.

an interval of about 24 hours, coming on commonly in the morning.

I. With the interposition of an apyrexia.

1. Varies in being solitary.

A, Universal.

B, Partial.

2. Complicated with other diseases.

II. With a remission only between the paroxsyms.

Sect. II. *Continuæ*. Fevers without evident intermission, and not occasioned by marsh miasmata; but attended with exacerbations and remissions, though not always very remarkable.

Genus IV. Synocha. Great heat; a frequent, strong, and hard pulse; high-coloured urine; the functions of the sensorium a little disturbed.

Genus V. Typhus. A contagious disease; the heat not much above the natural; the pulse small, weak, and for the most part frequent; the urine little changed; the functions of the sensorium very much disturbed, and the strength greatly diminished.

The species are,

I. Typhus *petechialis*. Typhus for the most part with petechiæ.

Varying in degree. 1. Mild typhus. 2. Malignant typhus.

II. Typhus *icterodes*. Typhus with a yellowness of the skin.

Genus VI. Synochus. A contagious disease. A fever compounded of synocha and typhus; in the beginning a synocha, but towards the end a typhus.

Order II. PHLEGMASIÆ. A synocha fever, with inflammation or topical pain, the internal function of the parts being at the same time injured; the blood drawn and concreted exhibiting a white coriaceous surface.

Genus VII. Phlogosis. Pyrexia; redness, heat, and painful tension, of some external part.

The species are,

I. Phlogosis (*phlegmone*) of a vivid red colour; a swelling well defined, for the most part elevated to a point, and frequently degenerating into an abscess, with a beating or throbbing pain.

The variations are, 1. In the form. 2. In the situation.

II. Phlogosis (*erythema*) of a reddish colour, vanishing by pressure; of an unequal and creeping circumference, with scarce any swelling; ending in the scaling off of the cuticle, in pustules, or blisters.

The variations are, 1. In the degree of violence. 2. In the remote cause. 3. In being complicated with other diseases.

The consequences of a phlogosis are, an imposthume, gangrene, sphacelus.

Genus VIII. Ophthalmia. A redness and pain of the eye, with an inability to bear the light; for the most part with an effusion of tears.

The species and varieties of the ophthalmia are,

I. Idiopathic.

1. Ophthalmia (*membranarum*), in the tunica adnata, and the membranes lying under it, or the coats of the eye.

A, Varying in the degree of the external inflammation.

B, In the internal coats affected.

2. Ophthalmia (*tarsi*), of the eye-lids, with swelling, erosion, and glutinous exudation.

II. Symptomatic.

1. From a disease of the eye itself.

2. From diseases of other parts, or of the whole body.

Genus IX. Phrenitis. Violent pyrexia; pain of the head; redness of the face and eyes; inability to endure the light or any noise; watchfulness; a furious delirium, or typhomania.

I. Idiopathic.

II. Symptomatic.

Genus X. Cynanche. Pyrexia sometimes inclining to a typhus; difficulty of swallowing and breathing; with a sensation of narrowness in the fauces.

The species are,

I. Cynanche (*tonsillaris*) affecting the mucous membrane of the fauces, but especially the tonsils, with redness and swelling, accompanied with a synocha.

II. Cynanche (*maligna*) affecting the tonsils, and mucous membrane of the fauces with swelling, redness, and mucous crusts of a whitish or ash-colour, creeping, and covering ulcers; with a typhous fever and exanthemata.

III. Cynanche (*trachealis*) attended with difficult respiration, noisy and hoarse inspiration, loud cough, without any apparent tumour in the fauces, somewhat difficult deglutition, and a synocha.

IV. Cynanche (*pharyngæa*) attended with redness in the bottom of the fauces, very difficult and painful deglutition, respiration sufficiently free, and a synocha.

V. Cynanche (*parotidæa*) when great swelling in the parotids and maxillary glands appearing on the outside; the respiration and deglutition but little injured; a synocha, for the most part mild.

Diseases of this genus are symptomatic, either from external or internal causes.

Genus XI. Pneumonia. Pyrexia, with a pain in some part of the thorax, difficult respiration, and cough. The species are,

I. Peripneumony, with a pulse not always hard, but sometimes soft; an obtuse pain of the breast; the respiration always difficult; sometimes the patient cannot breathe unless in an upright posture; the face swelled, and of a livid colour; the cough for the most part moist, frequently bloody.

1. Simple idiopathic peripneumonics.

Varying in degree.

2. Idiopathic peripneumonies complicated with fever.

3. Symptomatic peripneumonies.

II. Pleurisy, with a hard pulse; for the most part attended with a pungent pain of one side, augmented chiefly during the time of inspiration; an uneasiness when lying on the side; a most painful cough, dry in the beginning of the disease, afterwards moist, and frequently bloody.

1. Simple idiopathic pleurisies.

2. Pleurisies, complicated, (1.) With fever. (2.) With catarrh.

3. Symptomatic pleurisies.

4. False pleurisies.

The consequences of pleurisy are a vomica or empyema.

Genus XII. Carditis. Pyrexia; pain about the heart; anxiety; difficulty of breathing; cough; unequal pulse; palpitation of the heart, and fainting.

I. Idiopathic.

II. Symptomatic.

Genus XIII. Peritonitis. Pyrexia; pain of the belly, exasperated by an upright posture, without the proper signs of other abdominal phlegmasiæ.

I. Peritonitis (*propria*), situated in the peritonæum, properly so called, surrounding the inside of the abdomen.

II. Peritonitis (*omentalis*), in the peritonæum extended through the omentum.

III. Peritonitis (*mesenterica*), in the peritonæum spread through the mesentery.

Genus XIV. Gastritis. Pyrexia inclining to a typhus; anxiety; pain and heat of the epigastrium, augmented when any thing is taken into the stomach; an inclination to vomit, and an immediate rejection of every thing swallowed; an hiccough.

I. Idiopathic.

1. From external causes.

A, Gastritis (*phlegmonodæa*), attended with acute pain and violent pyrexia.

2. From external causes.

B, Gastritis (*erysipelatosa*), with a less violent fever and pain: an erysipelatous redness appearing on the fauces.

II. Symptomatic.

Genus XV. Enteritis. Pyrexia of a typhous nature; pungent pain of the belly, stretching and twisting about the navel; vomiting; the belly obstinately bound.

I. Idiopathic.

1. Enteritis (*phlegmonodæa*), with acute pain, violent fever, vomiting, and constipation of the belly.

2. Enteritis (*erysipelatosa*), with less acute fever and pain, without vomiting; but accompanied with a diarrhœa.

II. Symptomatic.

Genus XVI. Hepatitis. Pyrexia; tension and pain of the right hypochondrium; sometimes pungent like that of a pleurisy, but more frequently obtuse; a pain reaching to the clavicle and top of the right shoulder; a difficulty of lying on the left side; dyspnœa; dry cough, vomiting, and hiccough.

Genus XVII. Splenitis. Pyrexia; tension, heat, and swelling of the left hypochondrium, the pain increasing by pressure; without the signs of nephritis.

Genus XVIII. Nephritis. Pyrexia; pain in the region of the kidney, often following the course of the ureter: frequent discharge of urine, either thin and colourless, or very red; vomiting; stupor of the thigh; with a retraction or pain of the testicle of the same side. The species are,

I. Idiopathic. Spontaneous.

II. Symptomatic.

Genus XIX. Cystitis. Pyrexia; pain and swelling of the hypogastrium: frequent and painful discharge of urine, or ischuria; and tenesmus. The species are,

I. Those arising from internal causes.

II. Those from external causes.

Genus XX. Hysteritis. Pyrexia; heat, tension, swelling, and pain of the hypogastrium; the os uteri painful when touched; vomiting.

Genus XXI. Rheumatismus. A disease arising from an external and frequently very evident cause; pyrexia; pain about the joints, frequently following the course of the muscles; infesting the knees and other large joints rather than those of the feet or hands; increased by external heat.

The species are either idiopathic or symptomatic. The former varies in situation.

A, In the muscles of the loins.

B, In the muscles of the coxendix.

C, In the muscles of the breast.

Genus XXII. Odontalgia; a rheumatism of the jaws from a caries of the teeth.

Genus XXIII. Podagra. An hereditary disease, arising without any evident external cause, but for the most part preceded by an unusual affection of the stomach; pyrexia; pain of a joint for the most part of the great toe of the foot, at least infesting chiefly the wrists and ankles; returning by intervals; and often alternated with affections of the stomach and other internal parts.

I. Podagra (*regularis*), with a pretty violent inflammation of the joints remaining for some days, and by degrees going off with swelling, itching, and desquamation of the affected part.

II. Podagra (*atonica*), with an atony of the stomach, or some other internal part; and either without the usual inflammation of the joints, or only with slight and wandering pains; and frequently alternated with dyspepsia, or other symptoms of atony.

III. Podagra (*retrograda*), with the inflammation of the joints suddenly disappearing, and an atony of the stomach and other parts immediately following.

IV. Podagra (*aberrans*), with the inflammation of an internal part either preceding or not, and suddenly disappearing.

Genus XXIV. Arthropuosis. Deep, obtuse, and long-continued pains of the joints or muscular parts, frequently following contusions; with either no swelling, or a moderate and diffused one; no phlogosis; pyrexia, at first gentle, afterwards hectic, and at length an imposthume.

Order III. Exanthemata. Contagious diseases; affecting a person only once in his life; beginning with fever; after a certain time appear phlogoses, for the most part small and in considerable number, and dispersed over the skin.

Genus XXV. Erysipelas. A synocha of two or three days, for the most part attended with drowsiness, often with a delirium. In some parts of the skin, most frequently the face, appears a phlogosis. The species are,

I. Erysipelas (*vesiculosum*), with erythema, redness creeping, occupying a large space, and in some parts ending in large blisters.

II. Erysipelas (*phlyctænodes*), with an erythema formed of a number of papulæ, chiefly occupying the trunk of the body, ending in phlyctenæ or small blisters.

The disease is also symptomatic.

Genus XXVI. Pestis. An exceedingly contagious typhus, with the highest debility. On an uncertain day of the disease buboes and carbuncles break forth. It is various in degree, but the species are uncertain.

Genus

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Genus XXVII. Variola; a contagious synocha, with vomiting, and pain on pressing the epigastrium. On the third day begins, and on the fifth is finished, the eruption of inflammatory pustules, which suppurate in the space of eight days, and at last go off in crusts; frequently leaving depressed cicatrices or pockpits in the skin. The species are,

I. Variola (*discreta*), with few distinct, turpid pustules, having circular bases; the fever ceasing immediately after the eruption.

II. Variola (*confluens*), with numerous, confluent, irregularly shaped pustules, flaccid and little elevated; the fever remaining after the eruption.

Genus XXVIII. Varicella. Synocha; papulæ breaking out after a short fever, similar to those of the small-pox, but hardly ever coming to suppuration; after a few days going off in small scales, without leaving any mark.

Genus XXIX. Rubeola. A contagious synocha, with sneezing, epiphora, and dry hoarse cough. On the fourth day, or a little later, break forth small, clustered, and scarcely elevated papulæ; after three days going off in very small branny scales.

I. Rubeola (*vulgaris*), with very small confluent corymbose papulæ, scarcely rising above the skin.

Varying,

1. In the symptoms being more severe, and the course of the disease less regular.

2. In being accompanied with a cynanche.

3. With a putrid diathesis.

II. Rubeola (*variolodes*), with distinct papulæ, raised above the skin.

Genus XXX. Miliaria. Synochus with anxiety, frequent sighing, unctuous sweat, and a sense of pricking as of pin points in the skin. On an uncertain day of the disease, break out red, small, distinct papulæ, spread over the whole body as well as the face; the apices of which, after one or two days, become very small white pustules, remaining for a short time.

Genus XXXI. Scarlatina. A contagious synocha. On the fourth day of the disease the face swells a little; at the same time an universal redness occupies the skin in large spots, at length running together; after three days going off in branny scales; frequently succeeded by an anasarca. The species are,

I. Scarlatina (*simplex*), not accompanied with cynanche.

II. Scarlatina (*cynanchica*), with an ulcerous cynanche.

Genus XXXII. Urticaria. A quotidian fever. On the second day of the disease, red spots resembling the stinging of nettles, almost vanishing during the day, but returning during the evening with the fever, and after a few days going off altogether in very small scales.

Genus XXXIII. Pemphigus. A contagious typhus. On the first, second, or third day of the disease, blisters break out in several parts of the body, of the bigness of a bean, remaining for many days, and at last pouring out a thin ichor.

Genus XXXIV. Aphtha. Synochus; the tongue somewhat swelled and of a livid colour, as well as the fauces; eschars first appearing in the fauces, but at length occupying the whole internal parts of the mouth, of a white colour, sometimes distinct, often running together, quickly growing again when taken off; and remaining for an uncertain time.

The species are, 1. Idiopathic. 2. Symptomatic.

Order IV. Hæmorrhagiæ. Pyrexia, with a discharge of blood, without any external violence: the blood drawn from a vein hath the same appearance as in phlegmasiæ.

Genus XXXV. Epistaxis. Pain or weight of the head, redness of the face; a discharge of blood from the nose.

I. Idiopathic.

Varying according to the time of life.

1. Epistaxis of young people, with symptoms of an arterial plethora.

2. Epistaxis of old people, with symptoms of a venous plethora.

II. Symptomatic.

1. From internal causes.

2. From external causes.

Genus XXXVI. Hæmoptysis. Redness of the cheeks; a sensation of uneasiness, or pain, and sometimes of heat in the breast; difficulty of breathing; tickling of the fauces; either a severe or less violent cough, bringing up florid and frequently frothy blood.

The idiopathic species are,

1. Hæmoptysis (*plethorica*), without any external violence, and without being preceded by any cough or suppression of any customary evacuation.

2. Hæmoptysis (*violenta*), from external violence applied.

3. Hæmoptysis (*phthisica*), after a long-continued cough, with a leanness and debility.

4. Hæmoptysis (*calculosa*), in which some calculous molecules, for the most part of a calcareous nature, are thrown up.

5. Hæmoptysis (*vicaria*), after the suppression of a customary evacuation.

Besides these, there are a number of symptomatic species mentioned by different authors. The consequence of an hæmoptysis is, a

Phthisis. A wasting and debility of the body, with a cough, hectic fever, and for the most part a purulent expectoration. The species are,

I. An incipient phthisis, without any expectoration of pus.

II. A confirmed phthisis, with an expectoration of pus.

Both species vary, 1. As to their remote cause. 2. As to the origin of the purulent matter.

Genus XXXVII. Hæmorrhois. Weight and pain of the head; vertigo; pain of the loins; pain of the anus; livid painful tubercles, from which for the most part blood flows out; which sometimes also drops out of the anus, without any apparent tumor. The species are,

1. Hæmorrhois (*tumens*), external from mariscæ.

Varying,

A, Bloody.

B, Mucous.

2. Hæmorrhois (*procidens*), external from a *procidentia ani*.

3. Hæmorrhois (*fluens*), internal, without any swelling, or *procidentia ani*.

4. Hæmorrhois

4. Hæmorrhois (*cæca*), with pain and swelling of the anus, without any profusion of blood.

Genus XXXVIII. Menorrhagia. Pains of the back, belly, and loins, like those of child-birth; an unusually copious flux of the menses or blood from the vagina. The species are,

1. Menorrhagia (*rubra*), bloody in women neither with child nor in child-birth.

2. Menorrhagia (*abortus*), bloody in women with child.

3. Menorrhagia (*lochialis*), bloody in women after delivery.

4. Menorrhagia (*vitiorum*), bloody from some local disease.

5. Menorrhagia (*alba*), serous, without any local disease, in women not pregnant.

6. Menorrhagia (*Nabothi*), serous in women with child.

Order V. Profluvia. Pyrexia, with an increased excretion, naturally not bloody.

Genus XXXIX. Catarrhus. Pyrexia, frequently contagious; an increased excretion of mucus, at least efforts to excrete it.

The species are,

1. From cold.

2. From contagion.

Genus XL. Dysenteria. Contagious pyrexia; frequent mucous or bloody stools, while the alvine fæces are for the most part retained; gripes; tenesmus.

Varying,

1. Accompanied with worms.

2. With the excretion of small fleshy or sebaceous bodies.

3. With an intermittent fever.

4. Without blood,

5. With a miliary fever.

Class II. NEUROSES. A preternatural affection of sense and motion, without an idiopathic pyrexia or any local affection.

Order I. Comata. A diminution of voluntary motion, with sleep, or a deprivation of the senses.

Genus XLI. Apoplexia. Almost all voluntary motion abolished, with sleep more or less profound; the motion of the heart and arteries remaining.

The idiopathic species are,

1. Apoplexia (*sanguinea*), with symptoms of universal plethora, especially of the head.

2. Apoplexia (*serosa*), with a leucophlegmatia over the whole body, especially in old people.

3. Apoplexia (*hydrocephalica*), coming on by degrees; affecting infants, or those below the age of puberty, first with lassitude, a slight fever and pain of the head, then slowness of the pulse, dilatation of the pupil of the eye, and drowsiness.

4. Apoplexia (*atrabiliaria*), taking place in those of a melancholic constitution.

5. Apoplexia (*traumatica*), from some external injury mechanically applied to the head.

6. Apoplexia (*venenata*) from powerful sedatives taken internally or applied externally.

7. Apoplexia (*mentalis*), from an affection or emotion of the mind.

8. Apoplexia (*cataleptica*), the muscles remaining contractile, by external motion of the limbs.

9. Apoplexia (*suffocata*), from some external suffocating power.

The apoplexy is frequently symptomatic.

1. Of an intermittent fever. 2. Continued fever. 3. Phlegmasia. 4. Exanthema. 5. Hysteria. 6. Epilepsia. 7. Podagra. 8. Worms. 9. Ischuria. 10. Scurvy.

Genus XLII. Paralysis. Only some of the voluntary motions impaired, frequently with sleep.

The idiopathic species are,

1. Paralysis (*partialis*) of some particular muscles only.

2. Paralysis (*hemiplegica*) of one side of the body. Varying according to the constitution of the body.

a, Hemiplegia in a plethoric habit.

b, In a leucophlegmatic habit.

3. Paralysis (*paraplegica*) of one half of the body taken transversely.

4. Paralysis (*venenata*) from sedative powers applied either internally or externally.

A symptom either of an Asthenia or Palsy is,

Tremor; an alternate motion of a limb by frequent strokes and intervals.

The species are, 1. Asthenic. 2. Paralytic. 3. Convulsive.

Order II. Adynamiæ. A diminution of the involuntary motions, whether vital or natural.

Genus XLIII. Syncope; a diminution, or even a total stoppage, of the motion of the heart for a short time.

I. Idiopathic.

1. Syncope (*cardiaca*), returning frequently without any manifest cause, with violent palpitations of the heart during the intervals.—From a fault of the heart or neighbouring vessels.

2. Syncope (*occasionalis*) arising from some evident cause.—From an affection of the whole system.

II. Symptomatic; of diseases either of the whole system, or of other parts besides the heart.

Genus XLIV. Dyspepsia. Anorexia, nausea, vomiting, inflation, eructation, rumination, cardialgia, gastrodynia, more or fewer of those symptoms at least concurring; for the most part with a constipation of the belly, and without any other disease either of the stomach itself, or of other parts.

I. Idiopathic.

II. Symptomatic.

1. From a disease of the stomach itself.

2. From a disease of other parts, or of the whole body.

Genus XLV. Hypochondriasis. Dyspepsia, with languor, sadness and fear, without any adequate causes, in a melancholy temperament.

Genus XLVI. Chlorosis. Dyspepsia, or a desire of something not used as food; a pale or discoloured complexion; the veins not well filled: a soft tumor of the whole body; asthenia; palpitation; suppression of the menses.

Order III. Spasmi. Irregular motions of the muscles or muscular fibres.

Sect. I. *In the animal functions.*

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Genus XLVII. Tetanus. A spastic rigidity of almost the whole body.

Varying according to the remote cause, as it rises either from something internal, from cold, or from a wound. It varies likewise, from whatever cause it may arise, according to the part of the body affected.

Genus XLVIII. Trismus. A spastic rigidity of the lower jaw.—The species are,

1. Trismus (*nascentium*), attacking infants under two months old.

2. Trismus (*traumaticus*), attacking people of all ages either from a wound or cold.

Genus XLIX. Convulsio.—An irregular clonic contraction of the muscles without sleep.

I. Idiopathic.

II. Symptomatic.

Genus L. Chorea, attacking those who have not yet arrived at puberty, most commonly within the 10th or 14th year, with convulsive motions for the most part of one side in attempting the voluntary motion of the hands and arms, resembling the gesticulations of mountebanks; in walking, rather dragging one of their feet than lifting it.

Genus LI. Raphania. A spastic contraction of the joints, with a convulsive agitation, and most violent periodical pain.

Genus LII. Epilepsia. A convulsion of the muscles, with sleep.

The idiopathic species are,

1. Epilepsia (*cerebralis*), suddenly attacking without any manifest cause, without any sense of uneasiness preceding, excepting perhaps a slight vertigo or dimness of sight.

2. Epilepsia (*sympathica*), without any manifest cause, but preceded by the sensation of a kind of air rising from a certain part of the body towards the head.

3. Epilepsia (*occasionalis*), arising from a manifest irritation, and ceasing on the removal of that irritation.

Varying according to the difference of the irritating matter. And thus it may arise,

From injuries of the head; pain; worms; poison; from the repulsion of the itch, or an effusion of any other acrid humour; from crudities in the stomach; from passions of the mind; from an immoderate hæmorrhagy; or from debility.

Sect II. *In the vital functions.*

In the action of the heart.

Genus LIII. Palpitatio. A violent and irregular motion of the heart.

In the action of the lungs.

Genus LIV. Asthma. A difficulty of breathing returning by intervals, with a sense of straitness in the breast, and a noisy respiration with hissing. In the beginning of the paroxysm there is either no cough at all, or coughing is difficult; but towards the end the cough becomes free, frequently with a copious spitting of mucus.—The idiopathic species are,

1. Asthma (*spontaneum*), without any manifest cause or other concomitant disease.

2. Asthma (*exanthematicum*), from the repulsion of the itch or other acrid effusion.

3. Asthma (*plethoricum*), from the suppression of some customary sanguineous evacuation, or from a spontaneous plethora.

Genus LV. Dyspnœa. A continual difficulty of breathing, without any sense of straitness, but rather of fulness and infarction in the breast; a frequent cough throughout the whole course of the disease.

The idiopathic species are,

1. Dyspnœa (*catarrhalis*), with a frequent cough, bringing up plenty of viscid mucus.

2. Dyspnœa (*sicca*), with a cough for the most part dry.

3. Dyspnœa (*aëria*), increased by the least change of weather.

4. Dyspnœa (*terrea*), bringing up with the cough an earthy or calculous matter.

5. Dyspnœa (*aquosa*), with scanty urine and œdematous feet; without any fluctuation in the breast, or other signs of an hydrothorax.

6. Dyspnœa (*pinguedinosa*), in very fat people.

7. Dyspnœa (*thoracica*), from an injury done to the parts surrounding the thorax, or from some malconformation of them.

8. Dyspnœa (*extrinseca*), from evident external causes.

The symptomatic species of dyspnœa are consequences,

1. Of diseases of the heart or large vessels.

2. Of a swelling in the abdomen.

3. Of various other diseases.

Genus LVI. Pertussis. A contagious disease; convulsive strangulating cough reiterated with noisy inspiration; frequent vomiting.

Sect. III. *In the natural functions.*

Genus LVII. Pyrosis. A burning pain in the epigastrium, with plenty of aqueous humour, for the most part insipid, but sometimes acrid, belched up.

Genus LVIII. Colica. Pain of the belly, especially twisting round the navel; vomiting; and a constipation.

The idiopathic species are,

1. Colica (*spasmodica*), with retraction of the navel, and spasms of the abdominal muscles.

Varying, by reason of some symptoms superadded. Hence,

a, Colica, with vomiting of excrements, or of matters injected by the anus.

b, Colica, with inflammation supervening.

2. Colica (*pictonum*), preceded by a sense of weight or uneasiness in the belly, especially about the navel; then comes on the colic pain, at first slight and interrupted, chiefly augmented after meals: at length more severe and almost continual, with pains of the arms and back, at last ending in a palsy.

Varying according to the nature of the remote cause; and hence,

a, From metallic poison.

b, From acids taken inwardly.

c, From cold.

d, From a contusion of the back.

3. Colica (*stercorea*), in people subject to costiveness.

4. Colica (*accidentalis*), from acrid matter taken inwardly.

5. Colica (*meconialis*), in new-born children from a retention of the meconium.

6. Colica

6. Colica (*callosa*), with a sensation of stricture in some parts of the intestines, and frequently of a collection of flatus with some pain; which flatus also passing through the part where the stricture is felt, gradually vanishes; the belly slow, and at last passing only a few liquid fæces.

7. Colica (*calculosa*), with a fixed hardness in some part of the abdomen, and calculi sometimes passed by the anus.

Genus LIX. Cholera. A vomiting of bilious matter, and likewise a frequent excretion of the same by stool; anxiety; gripes; spasms in the calves of the legs.

I. Idiopathic.

1. Cholera (*spontanea*), arising in a warm season, without any manifest cause.

2. Cholera (*accidentalis*), from acrid matters taken inwardly.

II. Symptomatic.

Genus LX. Diarrhœa. Frequent stools; the disease not infectious; no primary pyrexia.

I. Idiopathic.

1. Diarrhœa (*crapulosa*), in which the excrements are voided in greater quantity than naturally.

2. Diarrhœa (*biliosa*), in which yellow fæces are voided in great quantity.

3. Diarrhœa (*mucosa*), in which either from acrid substances taken inwardly, or from cold, especially applied to the feet, a great quantity of mucus is voided.

4. Diarrhœa (*cœliaca*), in which a milky humour of the nature of chyle is discharged by stool.

5. Diarrhœa (*lienteria*), in which the aliments are discharged with little alteration soon after eating.

6. Diarrhœa (*hepatirrhœa*), in which a bloody serous matter is discharged without pain.

II. Symptomatic.

Genus LXI. Diabetes. A chronical profusion of urine, for the most part preternatural, and in immoderate quantity.

I. Idiopathic.

1. Diabetes (*mellitus*), with urine of the smell, colour, and taste of honey.

2. Diabetes (*insipidus*), with limpid, but not sweet, urine.

II. Symptomatic.

Genus LXII. Hysteria. Rumbling of the bowels; a sensation as of a globe turning itself in the belly, ascending to the stomach and fauces, and there threatening suffocation; sleep; convulsions; a great quantity of limpid urine; the mind involuntarily fickle and mutable.

The following are by Sauvages reckoned distinct idiopathic species; but, by Dr Cullen, only varieties of the same species.

A, From a retention of the menses.

B, From a menorrhagia cruenta.

C, From a menorrhagia serosa, or fluor albus.

D, From an obstruction of the viscera.

E, From a fault of the stomach.

F, From too great salacity.

Genus LXIII. Hydrophobia. A dislike and horror at any kind of drink, as occasioning a convulsion of the pharynx; induced, for the most part, by the bite of a mad animal. The species are,

I. Hydrophobia (*rabiosa*), with a desire of biting the bystanders, occasioned by the bite of a rabid animal.

II. Hydrophobia (*simplex*), without madness, or any desire of biting.

Order IV. Vesaniæ. Disorders of the judgment, without any pyrexia or coma.

Genus LXIV. Amentia; an imbecility of judgement, by which people either do not perceive, or do not remember, the relations of things. The species are,

I. Amentia (*congenita*), continuing from birth.

II. Amentia (*senilis*), from the diminution of the perceptions and memory through extreme old age.

III. Amentia (*acquisita*), occurring in people formerly of a sound mind, from evident external causes.

Genus LXV. Melancholia; a partial madness, without dyspepsia.

Varying according to the different subjects concerning which the person raves; and thus it is,

1. With an imagination in the patient concerning his body being in a dangerous condition, from slight causes; or his affairs in a desperate state.

2. With an imagination concerning a prosperous state of affairs.

3. With violent love, without satyriasis or nymphomania.

4. With a superstitious fear of a future state.

5. With an aversion from motion and all the offices of life.

6. With restlessness, and an impatience of any situation whatever.

7. With a weariness of life.

8. With a deception concerning the nature of the patient's species.

Dr Cullen thinks that there is no such disease as that called *dæmonomania*, and that the diseases mentioned by Sauvages under that title are either,

1. Species of melancholy or mania; or

2. Of some disease by the spectators falsely ascribed to the influence of an evil spirit; or

3. Of a disease entirely feigned; or

4. Of a disease partly true and partly feigned.

Genus LXVI. Mania; universal madness.

1. Mania (*mentalis*), arising entirely from passions of the mind.

2. Mania (*corporea*), from an evident disease of the body.

Varying according to the different disease of the body.

3. Mania (*obscura*), without any passion of mind or evident disease of the body preceding.

The symptomatic species of mania are,

1. Paraphrosyne from poisons.

2. Paraphrosyne from passion.

3. Paraphrosyne febrilis.

Genus LXVII. Oneirodynia. A violent and troublesome imagination in time of sleep.

1. Oneirodynia (*activa*), exciting to walking and various motions.

2. Oneirodynia (*gravans*), from a sense of some weight incumbent, and pressing on the breast especially.

General Arrangement of Diseases.

Class III. CACHEXIÆ; a depraved habit of the whole or greatest part of the body, without primary pyrexia or neurosis.

Order I. Marcores; emaciation of the whole body.

Genus LXVIII. Tabes. Leanness, asthenia, hectic fever. The species are,

1. Tabes (*purulenta*) from an external or internal ulcer, or from a vomica.

Varying in its situation: hence,

2. Tabes (*scrophulosa*), in scrophulous constitutions.

3. Tabes (*venenata*), from poison taken inwardly.

Genus LXIX. Atrophia. Leanness and asthenia, without hectic fever. The species are,

1. Atrophia (*inanitorum*), from too great evacuation.

2. Atrophia (*famelicorum*), from a want of nourishment.

3. Atrophia (*cacochymica*), from corrupted nourishment.

4. Atrophia (*debilium*), from the function of nutrition being depraved, without any extraordinary evacuation or cacochymia having preceded.

Order II. Intumescentiæ. An external swelling of the whole or greatest part of the body.

Sect. I. *Adiposæ*.

Genus LXX. Polysarcia; a troublesome swelling of the body from fat.

Sect. II. *Flatuosæ*.

Genus LXXI. Pneumatosis; a tense elastic swelling of the body, crackling under the hand. The species are,

1. Pneumatosis (*spontanea*), without any manifest cause.

2. Pneumatosis (*traumatica*), from a wound in the breast.

3. Pneumatosis (*veneneta*), from poison injected or applied.

4. Pneumatosis (*hysterica*), with hysteria.

Genus LXXII. Tympanites; a tense, elastic, sonorous swelling of the abdomen; costiveness: a decay of the other parts. The species are,

1. Tympanites (*intestinalis*), from a tumor of the abdomen frequently unequal, and with a frequent evacuation of air relieving the tension and pain.

2. Tympanites (*abdominalis*), with a more evident noise, a more equable tumor, and a less frequent emission of flatus, which also gives less relief.

Genus LXXIII. Physometra; a slight elastic swelling in the epigastrium, having the figure and situation of the uterus.

Sect. III. *Aquosæ* or *Dropsies*.

Genus LXXIV. Anasarca. A soft, inelastic swelling of the whole body, or some part of it. The species are,

1. Anasarca (*serosa*), from a retention of serum on account of the suppression of the usual evacuations, or from an increase of the serum on account of too great a quantity of water taken inwardly.

2. Anasarca (*oppilata*), from a compression of the veins.

3. Anasarca (*exanthematica*), arising after exanthemata, especially succeeding after erysipelas.

4. Anasarca (*anæmia*), from the thinness of the blood produced by hæmorrhagy.

5. Anasarca (*debilium*), in weak people after long diseases, or from other causes.

Genus LXXV. Hydrocephalus. A soft inelastic swelling of the head, with the sutures of the cranium opened.

Genus LXXVI. Hydrorachitis. A soft, slender tumour above the vertebræ of the loins; the vertebræ gaping from each other.

Genus LXXVII. Hydrothorax. Dyspnœa, paleness of the face; œdematous swellings of the feet; scanty urine; difficult lying in a recumbent posture; a sudden and spontaneous starting out of sleep, with palpitation; water fluctuating in the breast.

Genus LXXVIII. Ascites. A tense, scarce elastic, but fluctuating swelling of the abdomen. The species are,

1. Ascites (*abdominalis*), with an equal swelling of the whole abdomen, and with a fluctuation sufficiently evident.

Varying according to the cause.

A, From an obstruction of the viscera.

B, From debility.

C, From a thinness of the blood.

2. Ascites (*saccatus*), with a swelling in the abdomen, in the beginning at least, partial, and with a less evident fluctuation.

Genus LXXIX. Hydrometra. A swelling of the hypogastrium in women, gradually increasing, keeping the shape of the uterus, yielding to pressure, and fluctuating; without ischuria or pregnancy.

Genus LXXX. Hydrocele. A swelling of the scrotum, not painful; increasing by degrees, soft, fluctuating, and pellucid.

Sect. IV. *Solidæ*.

Genus LXXXI. Physconia. A swelling chiefly occupying a certain part of the abdomen, gradually increasing, and neither sonorous nor fluctuating. The species are,

Physconia hepatica.
Physconia splenica.
Physconia renalis.
Physconia uterina.
Physconia ab ovario.
Physconia mesenterica.
Physconia intestinalis.
Physconia omentalis.
Physconia polysplachna.
Physconia visceralis.
Physconia externa lupialis.
Physconia externa schirrhodea.
Physconia externa hydatidosa.
Physconia ab adipe subcutaneo.
Physconia ab excrescentia.

Genus LXXXII. Rachitis. A large head, swelling most in the fore part, the ribs depressed; abdomen swelled, with a decay of the other parts.

Varying,

1. Simple, without any other disease.

2. Joined with other diseases.

Order III. Impetigines. Cachexies chiefly deforming the skin and external parts of the body.

Genus

Genus LXXXIII. Scrophula. Swelling of the conglobate glands, especially in the neck; swelling of the upper lip and of the nose; the face florid, skin, thin, abdomen swelled. The species are,

1. Scrophula (*vulgaris*), simple, external and permanent.

2. Scrophula (*mesenterica*), simple, internal, with paleness of the face, want of appetite, swelling of the abdomen, and unusual fetor of the excrements.

3. Scrophula (*fugax*), most simple, appearing only about the neck; for the most part proceeding from the resorption of the matter of ulcers in the head.

4. Scrophula (*Americana*), joined with the yaws.

Genus LXXXIV. Syphilis. A contagious disease; ulcers of the tonsils, after impure venery, and a disorder of the genitals: clustered pimples of the skin, especially about the margin of the hair, ending in crusts and crusty ulcers; pains of the bones; exostoses.

Genus LXXXV. Scorbutus; in cold countries attacking after putrescent diet, especially such as is salt and of the animal kind, where no supply of fresh vegetables is to be had: asthenia; stomacace; spots of different colours on the skin, for the most part livid, and appearing chiefly among the roots of the hair.

Varying in degree.

a, Scorbutus incipiens.

b, Scorbutus crescens.

c, Scorbutus inveteratus.

Varying also in symptoms.

d, Scorbutus lividus.

e, Scorbutus petechialis.

f, Scorbutus pallidus.

g, Scorbutus ruber.

h, Scorbutus calidus.

Genus LXXXVI. Elephantiasis; a contagious disease; thick, wrinkled, rough, unctuous skin, destitute of hairs, anæsthesia in the extremities, the face deformed with pimples, the voice hoarse and nasal.

Genus LXXXVII. Lepra; the skin rough, with white, branny, and chopped eschars, sometimes moist beneath, with itching.

Genus LXXXVIII. Frambœsia; swellings resembling fungi, or the fruit of the mulberry or raspberry, growing on various parts of the skin.

Genus LXXXIX. Trichoma; a contagious disease; the hairs thicker than usual, and twisted into inextricable knots and cords.

Genus XC. Icterus; yellowness of the skin and eyes; white fæces; urine of a dark red, tinging what is put into it of a yellow colour.

The idiopathic species are,

1. Icterus (*calculosus*), with acute pain in the epigastric region, increasing after meals: biliary concretions voided by stool.

2. Icterus (*spasmodicus*), without pain, after spasmodic diseases, and passions of the mind.

3. Icterus (*hepaticus*), without pain, after diseases of the liver.

4. Icterus (*gravidarum*), arising during the time of pregnancy, and going off after delivery.

5. Icterus (*infantum*), coming on in infants a few days after birth.

Class IV. LOCALES. An affection of some part, but not of the whole body.

Order I. Dysæsthesiæ. The senses depraved or destroyed, from a disease of the external organs.

Genus XCI. Caligo. The sight impaired or totally destroyed, on account of some opaque substance interposed between the objects and the retina, inherent in the eye itself or the eyelids. The species are,

1. Caligo (*lentis*), occasioned by an opaque spot behind the pupil,

2. Caligo (*corneæ*), from an opacity of the cornea.

3. Caligo (*pupillæ*), from an obstruction of the pupil.

Varying according to the different causes from which it proceeds.

4. Caligo (*humorum*), from a disease or defect of the aqueous humour.

Varying according to the different state of the humour.

5. Caligo (*palpebrarum*), from a disease inherent in the eyelids.

Varying according to the nature of the disease in the eyelids.

Genus XCII. Amaurosis. The sight diminished, or totally abolished, without any evident disease of the eye; the pupil for the most part remaining dilated and immoveable. The species are,

1. Amaurosis (*compressionis*), after the causes and attended with the symptoms of congestion in the brain.

Varying according to the nature of the remote cause.

2. Amaurosis (*atonica*), after the causes and accompanied with symptoms of debility.

3. Amaurosis (*spasmodica*), after the causes and with the signs of spasm.

4. Amaurosis (*venenata*), from poison taken into the body or applied outwardly to it.

Genus XCIII. Dysopia. A depravation of the sight, so that objects cannot be distinctly perceived, except at a certain distance, and in a certain situation.

The species are,

1. Dysopia (*tenebrarum*), in which objects are not seen unless they be placed in a strong light.

2. Dysopia (*luminis*) in which objects are not distinctly seen unless by a weak light.

3. Dysopia (*dissitorum*), in which distant objects are not perceived.

4. Dysopia (*proximorum*), in which the nearest objects are not perceived.

5. Dysopia (*lateralis*), in which objects are not perceived unless placed in an oblique posture.

Genus XCIV. Pseudoblepsis; when the sight is diseased in such a manner that the person imagines he sees things which really do not exist, or sees things which do exist after some other manner than they really are. The species are,

1. Pseudoblepsis (*imaginaria*), in which the person imagines he sees things which really do not exist.

Varying according to the nature of the imagination.

2. Pseudoblepsis (*mutans*), in which objects really existing appear somehow changed.

Varying

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Varying according to the change perceived in the objects, and according to the remote cause.

Genus XCV. Dysecœa. A diminution or total abolition of the sense of hearing. The species are,

1. Dysecœa (*organica*), from a disease in the organs transmitting sounds to the internal ear.

Varying according to the nature of the disease and of the part affected.

2. Dysecœa (*atonica*), without any evident disease of the organs transmitting the sounds.

Varying according to the nature of the cause.

Genus XCVI. Paracusis; a depravation of the hearing. The species are,

1. Paracusis (*imperfecta*), in which though sounds coming from external objects are heard, yet it is neither distinctly nor in the usual manner.

Varying,

a, With a dulness of hearing.

b, With a hearing too acute and sensible.

c, When a single external sound is doubled by some internal causes.

d, When the sounds which a person desires to hear are not perceived, unless some other violent sound is raised at the same time.

2. Paracusis (*imaginaria*), in which sounds not existing externally are excited from internal causes.

Varying according to the nature of the sound perceived, and according to the nature of the remote cause.

Genus XCVII. Anosmia; a diminution or abolition of the sense of smell. The species are,

1. Anosmia (*organica*), from a disease in the membrane lining the internal parts of the nostrils.

Varying according to the nature of the disease.

2. Anosmia (*atonica*), without any evident disease of the membrane of the nose.

Genus XCVIII. Agheustia; a diminution or abolition of the sense of taste.

1. Agheustia (*organica*), from a disease in the membrane of the tongue, keeping off from the nerves those substances which ought to produce taste.

2. Agheustia (*atonica*), without any evident disease of the tongue.

Genus XCIX. Anæsthesia; a diminution or abolition of the sense of feeling. The species from Sauvages, adopted by Dr Cullen, are,

1. Anæsthesia à spina bifida.
2. Anæsthesia plethorica.
3. Anæsthesia nascentium.
4. Anæsthesia melancholica.

Order II. Dysorexiæ; error or defect of appetite.

Sect. I. *Appetitus erronei.*

Genus C. Bulimia; a desire for food in greater quantities than can be digested.

The idiopathic species are,

1. Bulimia (*helluonum*), an unusual appetite for food, without any disease of the stomach.

2. Bulimia (*syncopalis*), a frequent desire of meat, on account of a sensation of hunger threatening syncope.

3. Bulimia (*emetica*), an appetite for a great quantity of meat, which is thrown up immediately after it is taken.

Genus CI. Polydipsia; an appetite for an unusual quantity of drink.

The polydipsia is almost always symptomatic, and varies only according to the nature of the disease which accompanies it.

Genus CII. Pica; a desire of swallowing substances not used as food.

Genus CIII. Satyriasis; an unbounded desire of venery in men. The species are,

1. Satyriasis (*juvenilis*), an unbounded desire of venery, the body at the same time being little disordered.

2. Satyriasis (*furens*), a vehement desire of venery with a great disorder of the body at the same time.

Genus CIV. Nymphomania; an unbounded desire of venery in women.

Varying in degree.

Genus CV. Nostalgia; a violent desire in those who are absent from their country of revisiting it.

1. Nostalgia (*simplex*), without any other disease.

2. Nostalgia (*complicata*), accompanied with other diseases.

Sect. II. *Appetitus deficientes.*

Genus CVI. Anorexia. Want of appetite for food. Always symptomatic.

1. Anorexia (*humoralis*), from some humour loading the stomach.

2. Anorexia (*atonica*), from the tone of the fibres of the stomach being lost.

Genus CVII. Adipsia; a want of desire for drink. Always a symptom of some disease affecting the sensorium commune.

Genus CVIII. Anaphrodisia; want of desire for, or impotence to, venery.

The true species are,

1. Anaphrodisia paralytica.
2. Anaphrodisia gonorrhoica.

The false ones are,

1. Anaphrodisia à mariscis.
2. Anaphrodisia ab urethræ vitio.

Order III. Dyscinesiæ. An impediment, or depravation of motion from a disorder of the organs.

Genus CIX. Aphonia; a total suppression of voice without coma or syncope. The species are,

1. Aphonia (*gutturalis*), from the fauces or glottis being swelled.

2. Aphonia, (*trachealis*), from a compression of the trachea.

3. Aphonia (*atonica*), from the nerves of the larynx being cut.

Genus CX. Mutitas; a want of power to pronounce words. The species are,

1. Mutitas (*organica*), from the tongue being cut out or destroyed.

2. Mutitas (*atonica*), from injuries done to the nerves of the tongue.

3. Mutitas (*surdorum*), from people being born deaf, or the hearing being destroyed during childhood.

Genus CXI. Paraphonia; a depraved sound of the voice. The species are,

1. Paraphonia (*puberum*), in which, about the time of puberty, the voice from being acute and sweet, becomes more grave and harsh.

2. Paraphonia

2. Paraphonia (*rauca*), in which, by reason of the dryness or flaccid tumor of the fauces, the voice becomes rough and hoarse.

3. Paraphonia (*resonans*), in which, by reason of an obstruction in the nostrils, the voice becomes hoarse, with a sound hissing through the nostrils.

4. Paraphonia (*palatina*), in which, on account of a defect or division of the uvula, for the most part with a hare-lip, the voice becomes obscure, hoarse, and unpleasant.

5. Paraphonia (*clangens*), in which the voice is changed to one acute, shrill, and small.

6. Paraphonia (*comatosa*), in which, from a relaxation of the velum palati and glottis, a sound is produced during inspiration.

Genus CXII. Psellismus; a defect in the articulation of words. The species are,

1. Psellismus (*hæsitans*), in which the words, especially the first ones of a discourse, are not easily pronounced, and not without a frequent repetition of the first syllable.

2. Psellismus (*ringens*), in which the sound of the letter R is always aspirated, and, as it were, doubled.

3. Psellismus (*lallans*), in which the sound of the letter L becomes more liquid, or is pronounced instead of R.

4. Psellismus (*emolliens*), in which the hard letters are changed into the softer ones, and thus the letter S is much used.

5. Psellismus (*balbutiens*), in which, by reason of the tongue being large, or swelled, the labial letters are better heard, and often pronounced instead of others.

6. Psellismus (*acheilos*), in which the labial letters cannot be pronounced at all, or with difficulty.

7. Psellismus (*lagostomatum*), in which, on account of the division of the palate, the guttural letters are less perfectly pronounced.

Genus CXIII. Strabismus; the optic axes of the eyes not converging. The species are,

1. Strabismus (*habitualis*), from a bad custom of using only one eye.

2. Strabismus (*commodus*), from the greater debility or mobility of one eye above the other; so that both eyes cannot be conveniently used.

3. Strabismus (*necessarius*), from a change in the situation or shape of the parts of the eye.

Genus CXIV. Dysphagia; impeded deglutition, without phlegmasia or the respiration being affected.

Genus CXV. Contractura; a long-continued and rigid contraction of one or more limbs. The species are,

1 Contractura (*primaria*), from the muscles becoming contracted and rigid.

a, From the muscles becoming rigid by inflammation.

b, From muscles becoming rigid by spasm.

c, From muscles contracted by reason of their antagonists having become paralytic.

d, From muscles contracted by an irritating acrimony.

2. Contractura (*articularis*), from stiff joints.

Order IV. Apocenoses. A flux either of blood or some other humour flowing more plentifully than usual, without pyrexia, or an increased impulse of fluids.

Genus CXVI. Profusio; a flux of blood.

Genus CXVII. Ephidrosis; a preternatural evacuation of sweat.

Symptomatic ephidroses vary according to the nature of the diseases which they accompany, the different nature of the sweat itself, and sometimes the different parts of the body which sweat most.

Genus CXVIII. Epiphora; a flux of the lachrymal humour.

Genus CXIX. Ptyalismus; a flux of saliva.

Genus CXX. Enuresis; an involuntary flux of urine without pain. The species are,

1. Enuresis (*atonica*), after diseases injuring the sphincter of the bladder.

2. Enuresis (*irritata*), from a compression or irritation of the bladder.

Genus CXXI. Gonorrhœa; a preternatural flux of humour from the urethra in men, with or without a desire of venery. The species are,

1. Gonorrhœa (*pura*), in which, without any impure venery having preceded, a fluid resembling pus, without dysuria or propensity to venery, flows from the urethra.

2. Gonorrhœa (*impura*), in which, after impure venery, a mucous humour flows from the urethra with dysuria. The consequence of this is,

Gonorrhœa (*mucosa*), in which, after an impure gonorrhœa, a mucous humour flows from the urethra with little or no dysuria.

3. Gonorrhœa (*laxorum*), in which an humour for the most part pellucid, without any erection of the penis, but with a propensity to venery, flows from the urethra while the person is awake.

4. Gonorrhœa (*dormientium*), in which the seminal liquor is thrown out, with erection and desire of venery, in those who are asleep and have lascivious dreams.

Order V. Epischeses; suppressions of evacuations.

Genus CXXII. Obstipatio; the stools either suppressed, or slower than usual. The species are,

1. Obstipatio (*debilium*), in lax, weak, and for the most part dyspeptic persons.

2. Obstipatio (*rigidorum*), in people whose fibres are rigid, and frequently of an hypochondriac disposition.

3. Obstipatio (*obstructorum*), with symptoms of the colica, 1st, 2d, 4th, and 7th, above-mentioned.

Genus CXXIII. Ischuria; an absolute suppression of urine. The species are,

1. Ischuria (*renalis*), coming after a disease of the kidneys, with pain, or troublesome sense of weight in the region of the kidneys, and without any swelling of the hypogastrium, or desire of making water.

2. Ischuria (*ureterica*), coming after a disease of the kidneys, with a sense of pain or uneasiness in some part of the ureter, and without any tumour of the hypogastrium, or desire of making water.

3. Ischuria (*vesicalis*), with a swelling of the hypogastrium, pain at the neck of the bladder, and a frequent stimulus to make water.

4. Ischuria (*urethralis*), with a swelling of the hypogastrium, frequent stimulus to make water, and pain in some part of the urethra.

All these species are subdivided into many varieties, according to their different causes.

Genus CXXIV. Dysuria; a painful, and somehow impeded emission of urine. The species are,

1. Dysuria

General Arrangement of Diseases.

1. Dysuria (*ardens*), with heat of urine, without any manifest disorder of the bladder.

2. Dysuria (*spasmodica*), from a spasm communicated from the other parts to the bladder.

3. Dysuria (*compressionis*), from the neighbouring parts pressing upon the bladder.

4. Dysuria (*phlogistica*), from an inflammation of the neighbouring parts.

5. Dysuria (*irritata*), with signs of a stone in the bladder.

6. Dysuria (*mucosa*), with a copious excretion of mucus.

Genus CXXV. Dyspermatismus; a slow, impeded, and insufficient emission of semen in the venereal act. The species are,

1. Dyspermatismus (*urethralis*), from diseases of the urethra.

2. Dyspermatismus (*nodosus*), from knots on the corpora cavernosa penis.

3. Dyspermatismus (*præputialis*), from too narrow an orifice of the prepuce.

4. Dyspermatismus (*mucosus*), from mucus infarcting the urethra.

5. Dyspermatismus (*hypertonicus*), from too strong an erection of the penis.

6. Dyspermatismus (*epilepticus*), from a spasmodic epilepsy happening during the time of coition.

7. Dyspermatismus (*apractodes*), from an imbecility of the parts of generation.

8. Dyspermatismus (*refluus*), in which there is no emission of semen, because it returns from the urethra into the bladder.

Genus CXXVI. Amenorrhœa. The menses either flowing more sparingly than usual, or not at all, at their usual time, without pregnancy. The species are,

1. Amenorrhœa (*emansionis*), in those arrived at puberty, in whom, after the usual time, the menses have not yet made their appearance, and many different morbid affections have taken place.

2. Amenorrhœa (*suppressionis*), in adults, in whom the menses which had already begun to flow are suppressed.

3. Amenorrhœa (*difficilis*), in which the menses flow sparingly, and with difficulty.

Order VI. Tumores; an increased magnitude of any part without phlogosis.

Genus CXXVII. Aneurisma; a soft tumor, with pulsation, above an artery.

Genus CXXVIII. Varix; a soft tumour, without pulsation, above a vein.

Genus CXXIX. Ecchymoma; a diffused, little eminent, and livid tumour.

Genus CXXX. Schirrus; an hard tumour of some part, generally of a gland, without pain, and difficultly brought to suppuration.

Genus CXXXI. Cancer; a painful tumor of a schirrous nature, and degenerating into an ill conditioned ulcer.

Genus CXXXII. Bubo; a suppurating tumor of a conglobate gland.

Genus CXXXIII. Sarcoma; a soft swelling, without pain.

Genus CXXXIV. Verruca; a harder scabrous swelling.

Genus CXXXV. Clavus; a hard, lamellated thickness of the skin.

Genus CXXXVI. Lupia. A moveable, soft tumor below the skin, without pain.

Genus CXXXVII. Ganglion. A hard moveable swelling, adhering to a tendon.

Genus CXXXVIII. Hydatis; a cuticular vesicle filled with aqueous humour.

Genus CXXXIX. Hydarthrus; a most painful swelling of the joints, chiefly of the knee, at first scarce elevated, of the same colour with the skin, diminishing the mobility.

Genus CXL. Exostosis; a hard tumor adhering to a bone.

Order VII. Ectopiæ; tumors occasioned by the removal of some part out of its proper situation.

Genus CXLI. Hernia; an ectopia of a soft part as yet covered with the skin and other integuments.

Genus CXLII. Prolapsus; a bare ectopia of some soft part.

Genus CXLIII. Luxatio; the removal of a bone from its place in the joints.

Order VIII. Dialyses. A solution of continuity; manifest to the sight or touch.

Genus CXLIV. Vulnus; a recent and bloody solution of the unity of some soft part by the motion of some hard body.

Genus CXLV. Ulcus. A purulent or ichorous solution of a soft part.

Genus CXLVI. Herpes; a great number of phlyctenæ or small ulcers, gathering in clusters, creeping, and obstinate.

Genus CXLVII. Tinea; small ulcers among the roots of the hair of the head, pouring out a fluid which changes to a white friable scurf.

Genus CXLVIII. Psora. Itchy pustules and little ulcers of an infectious nature, chiefly infecting the hands.

Genus CXLIX. Fractura; bones broken into large fragments.

Genus CL. Caries; an ulceration of a bone.

Having thus presented to our readers Dr Cullen's general systematic view of all the diseases to which the human body is subjected, we next come to give a more particular account of the more important affections, treating of them in the order in which Dr Cullen has arranged them.

Class I. PYREXIÆ, or the Febrile Diseases.

Order I. FEBRES, Or Fevers strictly so called.

Sauvag. Class II. *Vog.* Class I. *Sagar.* Class XII. Morbi Febriles Critici, *Lin.* Class II.

Sect. I. INTERMITTENTS.

Intermittentes of many authors; *Sauv.* Class II. Order III. *Lin.* Class II. Order II. *Vog.* Class I. Order I. *Sag.* Class XII. Order III.

The

Fevres. The *remittentes* of others, *Sauv.* Class II. Order II.
Sag. Class XII. Order II.
Exacerbantes, *Lin.* Class II. Order III.
Continuæ, *Vog.* Class I. Order II.

Genus I. TERTIANA; the TERTIAN FEVER.

(*Tertiana*, Sauv. G. 88. Lin. 16. Hoffm. Stahl. Cleghorn. Senac.)

The *Genuine* TERTIAN.

26 (Tertiana legitima, *Senert. Hoffm. Cleghorn*, Minorc. *Sauv.* Sp. I.)

1. *Description.* This disease, in its most regular form, consists of repeated paroxysms, returning every second day, the patient during the intermediate period enjoying apparently a state of good health. This is the most common form of ague, as it is commonly called in Britain. Each paroxysm consists of three parts, the cold, the hot, and the sweating stages. The paroxysm commonly begins with a remarkable shivering, increasing frequently to a convulsive shaking of the limbs. The extremities are always cold, sometimes remarkably so. The cold for the most part is first perceived about the lumbar regions, from thence ascending along the spine it turns towards the pit of the stomach. Sometimes it begins in the first joint of the fingers and tip of the nose. Sometimes it attacks only a particular part of the body, as one of the arms, the side of the head, &c. This cold is often preceded by a heavy and sleepy torpor, languor, and lassitude, which we are partly to ascribe to real weakness and partly to mere languor. To these symptoms succeed yawning and stretching; after which the cold comes on as above described, not unfrequently with a pain of the back, and a troublesome sensation of tension in the precordia and hypochondria. To this succeed nausea and vomiting: and the more genuine the disease, the more certainly does the vomiting come on; by which a great deal of tough mucous matter, and sometimes bilious stuff or indigested food, is evacuated during the first paroxysm. In some there is only a violent straining to vomit, without bringing up any thing; sometimes, instead of these symptoms, a diarrhœa occurs, and this chiefly in weak, phlegmatic, and aged people, or where an indigested mucous saburra has long remained in the primæ viæ.

When these symptoms have continued for an hour or two, the cold begins to go off, and is succeeded by a lassitude, languor, and flaccidity of the whole body, but chiefly in the limbs, with an uneasy soreness as if the parts had been bruised; excepting in those cases where the nausea continues for a longer time. After this languor, a heat comes on, the increase of which is generally slow, but sometimes otherwise, with pain of the head, thirst, and bitterness in the mouth. The pulse is quick and unequal; sometimes beating 130 strokes in a minute. As soon as this heat has abated, a little moisture or sweat is observed to break forth; not always indeed in the first, but always in the succeeding paroxysms, and the urine lets fall a quantity of lateritious sediment. The whole paroxysm is seldom over in less than six hours, more frequently eight, and in violent cases it extends to 12 hours; but that which exceeds 12 hours is to be reckoned a spurious kind, and approaching to the nature of continued fevers. All these symptoms, however, are repeated every second day, in such a manner that the patient is quite free from fever for at least 24 hours. The paroxysms return much about the same time, though sometimes a little sooner or later. Tertiana.

2. *Causes of this disease and persons subject to it.* The genuine tertian attacks men rather than women, young people rather than old: the latter being more subject to anomalous tertians. It likewise seizes the lusty and active, rather than the lazy and indolent. Those, however, who are apt to nauseate their meat fall easily into a tertian fever. The cause, according to Dr Cullen, is the miasma of marshes, and that only. Other physicians have taken in many more causes, almost every thing indeed which debilitates the body: but the Doctor denies that any of these, though they may dispose the body for receiving the disease, or may augment it, can by any means produce it without the concurrence of the marsh miasma, and it cannot be denied, that it is a disease almost peculiar to marshy situations. Thus we find it very frequent in the fenny counties of Britain, although in other parts of this island it may be considered as a very rare disease; nay, in many it may perhaps be said that it never occurs. And it is also well known that intermittents have almost entirely disappeared in many parts of Britain, in which they were very common before the marshes of these places were drained.

3. *Prognosis.* The genuine simple tertian, unless improper medicines be administered, is generally very easily cured; nay, the vulgar reckon it of such a salutary nature, that after it they imagine a person becomes more strong and healthy than before. Hippocrates has observed, that these fevers terminate of their own accord after seven or nine paroxysms. Juncker tells us, that it frequently terminates before the seventh paroxysm, but rarely before the fourth. He also denies that any thing critical is to be observed in its going off; but in this he differs from Vogel, who tells us, that the urine, for some days after the fever is quite gone off, appears slimy, and lets fall much sediment. The latter also informs us, that besides the common crisis by sweat and urine, the tertian hath one peculiar to itself, namely, dry scabby ulcers breaking out upon the lips. These sometimes appear about the third or fourth paroxysm; and then we may venture to foretel that the disease will go off spontaneously after the seventh. But though the disease be never dangerous, in cold climates, at least, when properly treated; yet the improper use of hot and stimulating medicines may change it into a continued fever, more or less dangerous according to the quantity of medicines taken and the constitution of the patient; in which case the prognosis must be regulated by the particular symptoms which occur. In warm climates, however, the tertian fever may be considered as a much more alarming disease; and unless the most powerful remedies be employed, the patient is in danger of falling a victim to every paroxysm.

A variety of theories have been proposed for explaining the phenomena of this affection; but we may assert, that every thing hitherto said upon the subject is highly unsatisfactory. For although it be now almost universally admitted, that this fever does arise from the effluvia of marshes, yet in what manner the

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action of those effluvia induces fever, and particularly why this fever returns in regular paroxysms, are questions with regard to which we are still totally in the dark. Dr Cullen, with much ingenuity, attempted to prove, that the remote causes of this, as well as of other fevers, operate by inducing a state of debility; that this debility gives rise to spasm, which induces increased action, from which the phenomena are to be explained. But this theory is liable to no less numerous and unsurmountable objections than the exploded hypotheses which had before been proposed by others. For it is an undeniable truth, that debility often exists, even to the highest imaginable degree, without any fever; nay, that when fever has taken place, the debility is often much greater after it is entirely gone than at any period during its course. When spasm and increased action do take place, we have no reason to view them in any other light than merely as symptoms of the disease; and while they are often absent in this affection, they frequently occur in others where the sickness, anxiety, and other characterizing symptoms of fever are entirely absent: and, upon the whole, a probable or rational theory of intermittents, as well as of other fevers, still remains to be discovered.

Cure. The treatment of all genuine intermittents, whether *tertians*, quotidians, or quartans, being almost precisely the same, the general method of cure applicable to all of them may be here given, to which it will be easy to refer when we come to describe the others.

In treating intermittent fevers, physicians have formed indications of cure according to their different theories. The followers of Boerhaave, Stahl, &c. who imagined that the disease proceeded from a lentor or other disorders in the blood, always thought it necessary to correct and evacuate these peccant humours by emetics and purgatives, before they attempted to stop the disease by the Peruvian bark or any other medicine. Cinchona indeed, among some, seems to be held in very little estimation: since Vogel affirms, that this medicine, instead of deserving to have the preference of all other febrifuge medicines, ought rather to be ranked among the lowest of the whole; and for this reason he ascribes the cures, said to be obtained by the use of the Peruvian bark, entirely to nature.

According to Dr Cullen, the indications of cure in intermitting fevers may be reduced to the following:

1. In the time of intermission, to prevent the return of the paroxysms.

2. In the time of paroxysms, to conduct these in such a manner as to obtain a final solution of the disease.

3. To take off certain circumstances which might prevent the fulfilling of the two first indications.

The first indication may be answered in two ways: 1. By increasing the action of the heart and arteries some time before the period of accession, and supporting that increased action till the period of accession be over, and thus preventing the recurrence of that atony and spasm of the extreme vessels, which he thinks give occasion to the recurrence of paroxysms. 2. By supporting the tone of the vessels, and thereby preventing atony and the consequent spasm, without increasing the action of the heart and arteries, the recurrence of paroxysms may be prevented.

The action of the heart and arteries may be increased, 1. By various stimulant remedies internally given or externally applied, and that without exciting sweat. 2. By the same remedies, or by others, managed in such a manner as to excite sweating, and to support that sweating till the period of accession be for some time past. 3. By emetics, supporting for the same time the tone and action of the extreme vessels.

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The tone of the extreme vessels may be supported without increasing the action of the heart and arteries, by various tonic medicines; as, 1. Astringents alone. 2. Bitters alone. 3. Astringents and bitters conjoined. 4. Astringents and aromatics conjoined. 5. Certain metallic tonics; and, 6. Opiates. A good deal of exercise, and as full a diet as the condition of the patient's appetite and digestion allow, will be proper during the time of intermission, and may be considered as belonging to this head. Although many particulars in this plan of cure are deduced from Dr Cullen's theory, yet there can be no doubt that the object chiefly to be aimed at is to employ such remedies during the intermissions as will prevent a recurrence of the paroxysm. Of all the remedies hitherto employed with this intention, the most celebrated, perhaps the most certainly effectual, is the Peruvian bark; or, to speak more properly, the bark of the *Cinchona officinalis* of Linnæus. But it must be observed, that good effects are only to be expected from this medicine when employed in substance and in large quantity; and for its use the following rules or observations have been given:

1. The cinchona may with safety be employed at any period of intermitting fevers, providing that at the same time there be neither a phlogistic diathesis prevailing in the system, nor any considerable or fixed congestion present in the abdominal viscera.

2. The proper time for exhibiting the cinchona in intermittent fevers is during the time of intermission, and it is to be abstained from in the time of paroxysms.

3. In the case of genuine intermittents, while a due quantity of cinchona is employed, the exhibition of it ought to be brought as near to the time of accession as the condition of the patient's stomach will allow.

4. In all cases of intermittents, it is not sufficient that the recurrence of paroxysms be stopped for once by the use of the cinchona; a relapse is commonly to be expected, and should be prevented by the exhibition of the cinchona repeated at proper intervals.

The advantage of administering the medicine as early as possible, was fully ascertained by Dr Lind in the years 1765, 1766, and 1767, during an uncommon prevalence of intermittents. When the disease was stopped by the cinchona immediately after the first or second fit, which was the case with 200 of the Doctor's patients as well as himself, neither a jaundice nor dropsy ensued; whereas, when the cinchona could not be administered, on account of the imperfect intermission of the fever, or when the patient had neglected to take it, either a dropsy, jaundice, or constant headach, were the certain consequences, and the violence of the disease was in proportion to the number of the preceding fits, or to the continuance of the fever. By every paroxysm the dropsical swellings were visibly increased, and the colour of the skin rendered of a deeper yellow. When the fever continued a few days without intermission, the belly and legs generally swelled; a violent headach, likewise, and vertigo, for the most part distressed the patient;

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patient; so that some, even after the fever had left them, were not able to walk across their chamber for a fortnight or three weeks. When the returns of the fever were regular and even, but slight, four or five fits of a simple tertian were sometimes followed by the most dangerous symptoms; especially in the year 1765, when these fevers raged with the greatest violence. If, as frequently happened, a dropsical patient relapsed into the intermittent, there was an absolute necessity for putting an immediate stop to it by the cinchona; and in upwards of 70 such patients, Dr Lind observed the most beneficial effects to accrue from this practice. Without regard to a cough, or any other chronical indisposition, he ordered it to be given in large doses.

Cinchona has been often observed to fail in removing intermittents, from not continuing the use of it for a sufficient length of time, from administering it in too small a dose, or from giving it in an improper form. It was a prevailing opinion, that an ounce, or an ounce and a half, taken during one intermission, was sufficient to prevent the return of another paroxysm. But this is not always the case; for a severe fit will often attack a patient who has taken such a quantity. When this happens, the patient ought to persevere during the following intermissions, with an increase of the dose, till five or six ounces at least have been taken. The medicine also ought not to be omitted as soon as one fit is stopped, but should be continued in a smaller dose, and after longer intervals, for at least ten days or a fortnight. Even for several months after the disease is entirely removed, it would be advisable to take a little occasionally in damp weather, or during an easterly wind, to prevent a relapse. Where the intervals between the fits are short, as in quotidians and double tertians, from one to two drams of it ought to be taken every two or three hours.

The form in which this medicine is administered is of some consequence. Mucilages and syrups have been recommended to conceal the taste of it; but, from various experiments, Dr Lind found nothing more effectual for this purpose than small beer or milk, especially the latter. A dram of bark mixed with two ounces of milk, and quickly drank, may easily be taken by a person of the most delicate taste, and by washing the mouth afterwards with milk, there will not remain the least flavour of the bark; but if the mixture be not drank immediately, the bark will impart a bitter taste to the milk. This medicine is commonly given in electuaries or boluses; but Dr Lind observes, that in these forms it proves much less efficacious than when administered in juleps or draughts, with the plentiful addition of wine or spirits. He has remarked, that six drams of powdered bark, given in a julep, consisting of one-fourth or one-third of brandy, is as effectual as an ounce of the powder in the form of an electuary, and proves less disagreeable to the stomach. For patients unaccustomed to wine or spirits, each draught should be warmed with spiritus ammoniæ, or tinct. myrrh. by both of which the efficacy of the bark is he thinks increased. Dr Lind is also fully convinced that wine or spirits improve the virtues of the bark much more than elixir vitrioli, tinct. rosar. or such other medicines as have been recommended by different physicians.

For those who nauseate cinchona from a weakness of the stomach or other cause, he advises it to be given in clysters, in which form it is, he tells us, as efficacious as when taken by the mouth. For this purpose the extract is most proper with the addition of a sufficient quantity of the tinctura thebaica, in order to its being longer retained. For children labouring under intermitting fevers, Dr Lind orders the spine of the back to be anointed, at the approach of the fit, with a liniment composed of equal parts of tinctura thebaica and liniment. sapon. which has often prevented it. If this should not produce the desired effect, he informs us that two or three tea-spoonfuls of syrup. è mecon. given in the hot fit, will generally mitigate the symptoms. But for the entire removal of the disease, after purging with magnesia alba, he prescribes a dram of the extract. cinchonæ with a few drops of tinct. thebaic. in a clyster, to be repeated every three hours for a child of about a year old. When the stomach is oppressed with phlegm, the magnesia frequently occasions vomiting, which should be promoted with warm water. The constant heaviness of the head occasioned by those fevers in such tender constitutions is best relieved by the application of a blister to the back.

Cinchona has also proved effectual for the cure of intermittents in children, even when externally applied, by putting the powder of it into a quilted waistcoat. Of its efficacy in this way several instances are related by Dr Samuel Pye in the second volume of Medical Observations and Inquiries. In short, so effectual was it found in removing these fevers when properly applied, that of between four and five hundred afflicted with them in the year 1765, Dr Lind lost only two, neither of whom had taken this medicine.

In all these cases, a vomit was administered whenever the patient complained of a sickness and retching to vomit, or was seized with a spontaneous vomiting; and cinchona was never given till this sickness was removed, or a purgative taken to clear more perfectly the whole alimentary canal. In those patients who were troubled with a cough, attended with a pain in the side affecting the breathing, when the pain was not relieved by warm fomentations, the balsamum anodynum, or by a blister, Dr Lind generally ordered a few ounces of blood to be taken away, and endeavoured to stop the fever as soon as possible by the administration of cinchona; having found that every return of the fever increased all such pains.—When the headach was very violent, and harassed the patient during the intermissions, the success of cinchona was rendered more complete by the application of a blister to the back.—A giddiness of the head, which is the symptom most commonly remaining after even a slight intermitting fever, was generally relieved by the sal C. C. and cinchona in wine. The former of these was administered in the following manner.

℞. Aq. Alex. Simp. ℥vii.
Sal C. C. ʒss.
Syr. è Cort. Aurant. ℥i. M. f. julep. Cap. cochlear. ij. subindè.

If from the continuance of the fever the patient was distressed with a flatulence, a distention of the abdomen, and a swelling of the legs, a spoonful of tinctura sacra, with the addition of 30 drops of the spirit. lavend. compos. was ordered to be taken every night.—A continuance

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Such is the method of cure recommended by this experienced author, who has also discovered the efficacy and success of opium in intermitting fevers. He informs us, that he has prescribed an opiate to upwards of 300 patients labouring under this disease; and he observed, that, if taken during the intermission, it had not the least effect either in preventing or mitigating the succeeding paroxysm: when given in the cold fit, it once or twice seemed to remove it; but when given half an hour after the commencement of the hot fit, it generally gave immediate relief.—When given in the hot fit, the effects of opium are as follow: 1. It shortens and abates the fit; and this with more certainty than an ounce of cinchona is found to remove the disease. 2. It generally gives a sensible relief to the head, takes off the burning heat of the fever, and occasions a profuse sweat. This sweat is attended with an agreeable softness of the skin, instead of the burning sensation which affects patients sweating in the hot fit, and is always much more copious than in those who have not taken opium. 3. It often produces a soft and refreshing sleep to a patient tortured in the agonies of the fever, from which he awakes bathed in sweat, and in a great measure free from all complaints.

Dr Lind has always observed, that the effects of opium are more uniform and constant in intermitting fevers than in any other disease, and are then more quick and obvious than those of any other medicine. An opiate thus given soon after the commencement of the hot fit, by abating the violence and lessening the duration of the fever, preserves the constitution so entirely uninjured, that, since he used opium in agues, a dropsy or jaundice has seldom attacked any of his patients in those diseases. When opium did not immediately abate the symptoms of the fever, it never increased their violence. On the contrary, most patients reaped some benefit from an opiate given in the hot fit, and many of them bore a larger dose at that time than they could do at any other. He assures us, that even a delirium in the hot fit is not increased by opium, though opium will not remove it. Hence he thinks it probable, that many symptoms attending these fevers are spasmodic; but more especially the headach. However, if the patient be delirious in the fit, the administration of the opiate ought to be delayed until he recovers his senses, when it will be found greatly to relieve the weakness and faintness which commonly succeed the delirium. Dr Lind is of opinion, that opium in this disease is the best preparative for cinchona; as it not only produces a complete intermission, in which case alone that remedy can be safely administered; but occasions such a salutary and copious evacuation by sweat, as generally to render a much less quantity of cinchona requisite. He commonly prescribes the opiate in about two ounces of tinctura sacra, when the patient is costive, who is to take the cinchona immediately after the fit. By these means the paroxysm is shortened, and the intestines are cleansed, previous to the administration of cinchona; as the opiate doth not prevent, but only somewhat retards, the operation of the purgative. When a vomit is given immediately before the paroxysm, the administration of the opiate should be postponed till the hot fit be begun.

Tertian. In the administration of cinchona, care should be taken that it be of a good quality. And different opinions have been entertained with respect to the choice, even where there is no reason to believe that it has been adulterated by the mixture of other articles. For a long time, the preference was given to small quilled pieces of pale-coloured bark; but of late the red bark, which is generally in larger masses, of an apparently coarser texture, and evidently of a more resinous nature, has been highly celebrated by Dr Saunders and others. And in cases where it does not disagree with the stomach or excite looseness, it is admitted by the most accurate observers to be more powerful in preventing the return of intermittents. Whether the red bark be the product of a different species of the cinchona, or be obtained as well as the pale quilled bark from the cinchona officinalis, is not yet ascertained with sufficient accuracy. Cinchona of a yellow colour has lately been imported into Britain and highly extolled. Its botanical history is not ascertained. It contains more bitter extractive matter, and more tannin and gallic acid, than either the pale or red; but less gum than the pale, and less resin than the red. It seems to produce the same medical effects in smaller doses. And it has sometimes succeeded in the cure of intermittents where the pale and red cinchona have before been employed in vain.

A species of cinchona, distinguished by the title of *cinchona Jamaicensis*, has been discovered in Jamaica and other islands in the West Indies. A very accurate description of it has been given by Dr Wright of Jamaica in the Philosophical Transactions of London. The bark of this species also has been recommended in the cure of intermittents; but the advantages of it have not hitherto been sufficiently confirmed by experience.

The barks of various trees readily cultivated in Britain, particularly different species of the salix, the prunus, the fraxinus, and the quercus, have by some been represented as no less efficacious than the cinchona. But we may safely venture to assert, that although several of them may possess some power in stopping intermittents, yet that none hitherto tried can be considered as in any degree approaching to the cinchona in point of efficacy.

But although the Peruvian bark be the best cure for intermittents hitherto discovered, yet while it can by no means be represented as the only cure, it is very certain that other remedies have in different cases succeeded after the cinchona has failed. Cures have often been obtained by the use of different aromatics, bitters, and astringents. Many articles from the mineral kingdom also have been employed with advantage. And intermittents have unquestionably been in certain cases stopped by different preparations of iron, zinc, copper, lead, and mercury. But of all the articles of this nature, arsenic of late has been the most celebrated. Arsenic is on good grounds conjectured to be the basis of an article much employed in the cure of intermittents in some of the countries where they are most prevalent, and sold under the title of the *tasteless ague drop*. The great success attending the use of this article, led Dr Fowler, an ingenious physician of Stafford, to examine it with particular attention. And in a treatise which he has lately published, entitled *Medical Reports* on the effects of arsenic in the cure of agues, he has given a formula for an arsenical solution,

solution, which he has found very successful in affections of this kind, and which is probably very nearly the same with the tasteless ague drop. Dr Fowler's mineral solution, as he styles it, is formed by dissolving 64 grains of arsenic and as much fixed vegetable alkaline salt in a pound of distilled water. This solution is given in doses from three to 12 drops, varied according to the condition of the patient, and repeated two or three times a-day. And where the cinchona has failed in stopping intermittents, it seems to be one of the most powerful remedies yet discovered. But after all remedies prove ineffectual, intermittents are often stopped by a change of season and of situation.

But besides the remedies employed in tertians and other intermittents, with the view of preventing the return of paroxysms, it is often also necessary to employ powerful articles with other intentions, particularly to mitigate and shorten the paroxysm when present; to obviate urgent symptoms, especially those of an inflammatory or putrid nature; and to obtain a complete apyrexia or intermission from fever after the paroxysm has ceased. With these intentions, recourse is not unfrequently had to emetics, laxatives, blood-letting, opium, diluents, or sudorifics, as the circumstances of the case may require.

The *Irregular* or *Spurious* TERTIAN.

Sp. I. var. 1. B.

Tertiana notha sive spuria, *Sauv.* sp. 2. *Sennert. Cleghorn. Hoffman.*

The characteristic marks of this fever are, that its paroxysms last longer than 12 hours, and consequently it inclines more to the quotidian or continued fever than the former. Its paroxysms have no stated hour of attacking. The cure, however, is precisely the same with that above described, observing the proper cautions already mentioned with regard to the use of the cinchona.

The *Double* TERTIAN. Sp. 1. var. 2. C.

Tertiana duplex, *Sauv.* sp. 13. *Vog.* G. 12. *Sennert. Cleghorn.*
Duplicata, *Lin.* 18.

The double tertian comes on every day; but differs from the quotidian in this, that its paroxysms do not answer to each other singly, but alternately. The first day, for instance, the fit will come on in the forenoon, in the second in the afternoon, the third in the forenoon, and the fourth in the afternoon.

Of these fevers we shall give the following description from Cleghorn's treatise on the diseases of Minorca: "They are called *double tertians* when there are two fits and two intervals within the time of each period. But commonly there is some difference between the two fits, either in respect of the hour they come at, the time of their duration, or the nature and violence of their concomitant symptoms. Some double tertians begin in this manner.—On the evening of Monday, for example, a slight fit comes on, and goes off early next morning; but on Tuesday, towards the middle of the day, a more severe paroxysm begins, and continues till night. Then there is an interval to Wednesday evening, when a slight fit commences a new period of the fever, which proceeds in the same manner as the first; so that according to the way physicians calculate the days of diseases, (by beginning to reckon from the first hour of their invasion,) both paroxysms happen on the odd days, while the greatest part of the even days is calm and undisturbed. But in most double tertians the patient has a fit every day of the disease; the severe one commonly appearing at noon upon the odd days, the slight one towards evening on the even days; though sometimes the worst of two fits happen on the even days.

"There is a tertian fever sometimes to be met with, during each period of which there are three different fits, and as many intervals. For example, towards Monday noon the patient is seized with a paroxysm, which declines about five or six o'clock the same evening; a few hours after, another fit begins, and continues until morning; from which time there is an interval to Tuesday evening, when a third fit comes on, and lasts most part of the night. On Wednesday there are again two paroxysms, as on Monday, and on Thursday like that of Tuesday; and thus the fever goes on with a double fit on each of the odd days, and a single fit on the even days.

"In double tertians, that interval is the most considerable which follows the severe fit; for the slight fit oftener ends in a remission than intermission, and frequently lingers till the other approaches: Hence it is, that the night preceding the vehement fit is much more restless than that which comes after it, as has been observed by Hippocrates. In double tertians, the vehement fit often comes on a little earlier in each period, while the slight fit returns at the same hour, or perhaps later and later every second day: so that the motions of one have no influence on those of the other; from whence it appears that each of these fits hath its own proper independent causes."

Duplicated TERTIAN. Sp. I. var. 2. D. 129

Tertiana duplicata, *Sauv.* sp. 14. *Jones. River.*

This hath two fits on the same day, with an intermediate day on which there are none. This also does not differ in any remarkable particular from those already described.

The *Triple* TERTIAN. Sp. I. var. 2. D. 130

Tertiana triplex, *Sauv.* sp. 15. *Cleghorn.*
Semitertiana, *Hoffman.*
Semitertiana primi ordinis, *Spig.*

This differs from the former in having a single and double fit alternately: thus, for instance, if there be two fits the first day, there is only one the second, two the third, one the fourth, &c. Its cure is the same as before.

The *Semi*-TERTIAN. Sp. I. var. 2. F. 131

Hemitritæus, *Cels.*
Semitertiana, *Cleghorn.*
Semitertiana secundi ordinis, *Spig.*
Amphimerina hemitritæus, *Sauv.* sp. 8.
Amphimerina pseudo-hemitritæus, *Sauv.* sp. 9.

The semitertian is described by Dr Cullen as having only an evident *remission* between its paroxysms; more remarkable between the odd and even day, but less so between the even and odd one. For this reason, he adds, that possibly some semitertians ought rather to

Febres. to be classed among the remittents; and owns that it is difficult to settle the boundaries between them. But Cleghorn, whom he quotes, describes it in the following manner. "A fit begins on Monday noon, for example, and goes off the same night. On Tuesday afternoon a second fit comes on, and gradually increases till Wednesday night, when it terminates. On Thursday morning there is such another interval as happened on Tuesday morning: But on Thursday afternoon another long fit like the preceding commences; and returning regularly every second day, leaves only a short interval of ten or twelve hours during the eight and forty.

Concerning the cure of these fevers Dr Cullen observes, that though no entire apyrexia occurs, cinchona may be given during the remissions: and it should be given even though the remissions be inconsiderable; if, from the known nature of the epidemic, intermissions or considerable remissions are not to be expected, and that great danger is apprehended from repeated exacerbations.

132 The *Sleepy* TERTIAN. Sp. I. var. 3. G.

Tertiana carotica, *Sauv.* sp. 10. *Werlhof.*
Tertiana hemiplegica, *Sauv.* sp. 20. *Werlhof.*
Quotidiana soporosa, *Sauv.* sp. 8. *Car. Pis.*
Febris caput impetens, *Sydenham*, ep. ad. R. Brady.

This, according to Vogel, is a most dangerous species, and very commonly fatal; for which reason he ranks it amongst those intermittents which he calls *malignant*. Sometimes he tells us the alarming symptom of a sleepiness comes on, not at the beginning of the disease, but will unexpectedly occur during the third, fourth, fifth, or sixth paroxysm. It commonly begins with the cold fit, and continues during the whole time of the paroxysm, and, becoming stronger at every succeeding one, at last terminates in a mortal apoplexy. Sometimes fevers of this kind rage epidemically. Vogel relates, that he saw a simple tertian changed into one of these dangerous fevers. The patient was a woman of a delicate constitution, and the symptoms appeared in consequence of her being put in a violent passion: however, it occurred but once, and she recovered. Hoffman mentions a carus in a double tertian occurring seven times without proving mortal; though Vogel says, that the powers of nature are very seldom sufficient to conquer the disease.

In 1678, Dr Sydenham tells us that intermittents raged epidemically at London, where none had appeared before from 1664. Of them "it is to be noted (says he), that though quartans were most frequent formerly, yet now tertians or quotidians were most common, unless the latter be entitled double tertians: and likewise, that though these tertians sometimes began with chilness and shivering, which were succeeded first by heat, and soon after by sweat, and ended at length in a perfect intermission, returning again after a fixed time; yet they did not keep this order after the third or fourth fit, especially if the patient was confined to his bed and used hot cardiacs, which increase the disease. But afterwards this fever became so unusually violent, that only a remission happened in the place of an intermission; and approaching every day nearer the species of continued fevers, it seized the head, and proved fatal to abundance of persons."

From this description of Sydenham's we may have an idea of the nature of the disease. As to its cure he strongly recommends cinchona; telling us, that, e en in the *most continued* kind of intermittents, "the nearer the intermittent approaches to a continued fever, either spontaneously, or from using too hot a regimen, so much the more necessary is it to exhibit a larger quantity of the bark; and that he took advantage of a remission, though ever so small."

The *Spasmodic* or *Convulsive* TERTIAN. Sp. I. var. 3. H.

Tertiana asthmatica, *Sauv.* sp. 6. *Bonnet.*
Tertiana hysterica, *Sauv.* sp. 8. *Wedel.* A. N. C. Dec. I. A. II. obs. 193.
Hysteria febricosa, *Sauv.* G. 135. sp. 8. A. N. C. Dec. I. Ann. II.
Tertiana epileptica, *Sauv.* sp. 16. *Calder. Lautter.*
Quotidiana epileptica, *Sauv.* sp. 3. Edinb. Essays, vol. v. art. 49.
Ecclampsia febricosa, *Sauv.* G. 139. sp. 17.
Epilepsia febricosa, *Sauv.* G. 134. sp. 9.
Tertiana tetanodes Med. Beobacht I. Band.
Tetanus febricosus, *Sauv.* G. 122. sp. 10. *Stork.* Ann. Med. II.

Tertians of this kind occur with very different symptoms from those of the true ones, and sometimes even with those which are very extraordinary. In some they are attended with symptoms of asthma, in others with those of hysterics, in others with convulsions. Where the symptoms of asthma occur, the disease must be treated with diuretics and antispasmodics joined with cinchona. In the hysteric asthma the fit comes on with cold, yawning, cardialgia, terror and dejection of mind. The disease is to be removed by mild aperients and antihysterics joined with cinchona.

Of the convulsive tertian we have a most remarkable instance in the Edinburgh Medical Essays, vol. v. The patient was a farmer's son about 26 years of age, of a strong plethoric habit of body. He had laboured under an ague half-a year, and had taken a great deal of Peruvian bark. While he was telling his case to the surgeon (Mr Baine of Pembroke), he was suddenly taken with a violent stamping of his feet; and the convulsions gradually ascended from the soles of the feet to his legs, thighs, belly, back, and shoulders. His head was then most violently convulsed, with a total deprivation of speech; but he had a most dismal vociferation, which might have been heard at a considerable distance, his abdomen and thorax working and heaving violently and unusually in the mean time. This fit having lasted half an hour, a profuse sweat broke out over all his body, which relieved him; and he then became capable of answering such questions as were put. These extraordinary fits, he said, had been occasioned by a fright, and his neighbours had concluded that he was bewitched. They returned sometimes twice a-day, and always at the times the ague used to return. During the paroxysm his pulse was very high and quick, his face much inflamed, and his eyes ready to start out of his head. After the

the fit was over, he complained of a most torturing pain of the bowels. His tongue was generally moist, and he had a suppression of urine.—This formidable disease, however, was totally subdued by the use of cinchona, mercurials, antispasmodics, opiates, and saline draughts.

The *Eruptive* TERTIAN. Sp. I. var. 3. I.

Tertiana petechialis, *Sauv.* sp. 4. *Donat. Lautter.*

Tertiana scorbutica, *Wedel.* A. N. C. Dec. I. A. II. obs. 193.

Tertiana urticata, *Sauv.* sp. 22. *Planchon.* Journ. de Med. 1765. *Cleghorn.*

Tertiana miliaris, *Sauv.* sp. 21. *Walthieri* de Med. Ger.

This species of tertian is accompanied with red or livid blotches on the skin, or an eruption like that occasioned by the stinging of nettles. In the latter case Dr Cleghorn says the disease is very dangerous; and as the former indicates an incipient dissolution and putrefaction of the blood, it must also be reckoned of very dangerous tendency.

The *Inflammatory* TERTIAN. Sp. I. var. 3. K.

Tertiana pleuritica, *Sauv.* sp. 4. *Vales. Lautt.*

Pleuritis periodica, *Sauv.* G. 103. sp. 14.

Tertiana arthritica, *Sauv.* sp. 5. *Morton. Lautt.*

Sauvages informs us, that he has seen a true and genuine pleurisy having all the pathognomic signs of the disease, but assuming the form of an intermittent; that is, the patient is one day affected with the pleurisy, and the next seemingly in perfect health. He also tells us, that in the month of May 1760, a tertian raged epidemically, which after the third fit imitated a pleurisy, the pain of the side, and difficulty of breathing coming regularly on, and the fever from an intermittent becoming remittent; the blood had also the same appearance with that of pleuritic persons, and the distemper yielded to bleeding and gentle cathartics.—Morton also informs us, that he has observed similar disorders an hundred times, which were always certainly and safely cured by the Peruvian bark.

The TERTIAN *complicated* with other *Disorders.* Sp. I. var. 4.

Tertiana scorbutica, *Sauv.* sp. 9. *Etmuller, Timæus.*

Tertiana syphilitica, *Sauv.* sp. 17. *Deidier.*

Tertiana verminosa, *Sauv.* sp. 18. *Stisser.* in act. Helmstad. *Lancis.* de noxiis palud. *Pringle. Ramazzini. Van den Bosch.* de const. vermin.

The scorbutic tertian, according to Sauvages, is exceedingly anomalous, its periods being sometimes much anticipated, and sometimes much postponed. It is exceedingly obstinate, and will return if the body be not cleared of its scorbutic taint. The patient is affected with lancinating pains of a wandering nature. The urine lets fall a dusky red sediment, or a thick branny matter is copiously scattered up and down in it, seemingly tinged with blood. The usual symptoms of scurvy, viz. livid spots, and rotten fetid gums, also frequently occur. For this the Peruvian bark is very useful, both as a febrifuge and antiscorbutic.

A tertian accompanied with worms is taken notice of by Sir John Pringle in his treatise on the diseases of the army. The worms, he tells us, were of the round kind; and though we are by no means to reckon them the cause of the fever, they never failed to make it worse, occasioning obstinate gripings or sickness at stomach. In these cases stitches were frequent; but, being flatulent, were not often relieved by bleeding. The worms were discharged by vomiting as well as by stool. For discharging these worms, he commonly gave half a dram of rhubarb with 12 grains of calomel; without observing any inconvenience from such a large dose of mercury. Anthelmintics, which act slowly, had little chance of doing good; for though worms will sometimes lie long in the bowels without giving much uneasiness to a person otherwise well, yet in a fever, especially one of a putrid kind (to which his intermittents always seemed to incline), the worms being disturbed by the increase of heat, and the corruption of the humours in the *primæ viæ*, begin to move about, and struggle to get out. Lancisius, who makes this remark, adds, that upon opening the bodies of some who had died at Rome of fevers of this kind, wounds were found in the intestines made by the biting of the worms; nay, that some of them had even pierced through the coats of the guts, and lay in the cavity of the abdomen. Pringle never had any instance of this; but knew many cases in which the worms escaped by the patient's mouth, though there had been no previous retching to bring them up. One soldier was thrown into violent convulsions, but was cured by the above-mentioned powder.

The TERTIAN *varied* from its *Origin.* Sp. I. var. 5. 137

Tertiana accidentalis, *Sauv.* sp. 12. *Sydenham.*

Tertiana à scabie, *Sauv.* sp. 12. *Juncker*, tab. 80. *Hoffman*, II. p. 12.

The existence of fevers of this kind, as we have already observed, is denied by Dr Cullen; the accidental fever of Sauvages was said to arise from any slight error in the non-naturals, and consequently was very easily cured. That which arose from the repulsion of the itch, was cured as soon as the eruption returned.

The TERTIAN with only a *remission* between the fits. Sp. II. 138 Remittent tertian.

Tritæophya, *Sauv.* Gen. 85. *Sag.* p. 695.

Tritæus, *Lin.* 21.

Hemitritæa, *Lin.* 23.

Tertianæ remittentes et continuæ Auctorum.

Tertianæ subintrantes, proportionatæ, subcontinuæ, *Torti.*

Tertiana subcontinua, *Sauv.* sp. 19.

Quotidiana deceptiva, *Sauv.* sp. 2.

Amphimerina semiquintana, *Sauv.* sp. 24.

Tritæophya deceptiva, *Sauv.* sp. 10.

Causus *Hippocratis.*

Tritæophya causus, *Sauv.* sp. 2.

Febris ardens *Boerhaavii*, aph. 738.

Tertiana perniciosa, quæ simulata tertiani circuitus effigie lethalis, et mille accidentibus periculosissimis implicata, existit. *Lud. Mercatus.*

Tertiana pestilens, *P. Sal. Diversus.*

Tertiana

Febres.

Tertiana maligna pestilens, *Riverii.*
Morbus Hungaricus. *Lang. Lemb. Sennert. Jordan.*
Languor Pannonicus, *Cober.*
Amphimerina Hungarica, *Sauv.* sp. 10.
Hemitritæus pestilens, *Schenck.* ex *Corn. Gamma.*
Febres pestilentes Ægyptiorum, *Alpin.*
Febris tertiana epidemica, *Bartholin.*
Febres epidemicæ, autumni 1657 et 1658, *Willis.*
Febris syneches epidemica ab anno 1658 ad 1664. et postea ab anno 1673 ad 1691, *Morton.*
Febres autumnales incipientes, *Sydenham.*
Affectus epidemicus Leidensis, *Fr. Sylvii.*
Morbus epidemicus Leidensis. 1669, *Fanois.*
Tertianæ perniciosæ et pestilentes, et febres castrenses epidemicæ, *Lancisi.*
Febres intermittentes anomalæ et mali moris, *Hoffman.*
Febris cholerica minus acuta, *Hoffman.*
Febris epidemica Leidensis, anno 1719, *Koker* apud *Haller*, Disp. tom. v.
Amphimerina paludosa, *Sauv.* sp. 19.
Febris paludum, *Pringle.*
Bononiensis constitutio hiemalis 1729, *Beccari* in A. N. C. vol. iii.
Amphimerina biliosa, *Sauv.* sp. 22.
Febris castrensis, *Pringle.*
Febris putrida epidemica, *Huxham de aëre ad ann.* 1729.
Febris biliosa Lausanensis, *Tissot.*
Tritæophya Wratislaviensis. *Sauv.* sp. 3. Hahn. Epidemia verna Wratislav. in App. ad A. N. C. vol. x.
Tritæophya Americana, *Sauv.* sp. 12.
Febris anomala Batava, *Grainger.*
Morbus Naronianus, *Pujati.*
Febris continua remittens, *Hillary's* diseases of Barbadoes.
Febris remittens Indiæ Orientalis, *Lind.* diss. inaug. 1768.
Febris critica et febr. biliosa æstatis, *Rouppe.*
Febris remittens regionum calidarum, *Lind* on the diseases of hot climates.

A. Tertiana cholerica sive dysenterica, *Tort.* Therap. Special. lib. iii. cap. 1. *Lautter.* Hist. Med. cas. 6. 16. 17. 20. *Morton*, App. ad Exerc. II.

B. Tertiana subcruenta sive atrabiliaris, *Tort.* ibid. Never seen by *Cleghorn.*

C. Tertiana cardiaca, *Tort.* ibid. *Lautter.* Hist. Med. cas. 15. 16. 23.
Amphimerina cardiaca, *Sauv.* sp. 5.
Tritæophya assodes, *Sauv.* sp. 6.
Febris continua assodes, *Vog.* 27.

D. Tertiana diaphoretica, *Tort.* ibid.
Tritæophya typhodes, *Sauv.* sp. 4.
Tritæophya elodes, *Sauv.* sp. 5.
Febris continua elodes, *Vog.* 21.

E. Tertiana syncopalis, *Tort.* ibid. *Lautter.* case 11. 12. 13. 15. 16.
Tritæophya syncopalis, *Sauv.* sp. 1.
Amphimerina syncopalis, *Sauv.* sp. 4.
Amphimerina humorosa, *Sauv.* sp. 6.
Febris continua syncopalis, *Vog.* 29.

F. Tertiana algida, *Tort.* ibid. *Lautter.* cas. 13.
Amphimerina epiala, *Sauv.* sp. 3.
Amphimerina phricodes, *Sauv.* sp. 7.
Tritæophya leipyria, *Sauv.* sp. 9.
Tertiana leipyria, *Sauv.* sp. 23. *Valcarenghi* Med. Ration. p. 18.
Febris continua epiala et leipyria, *Vog.* 19. et 24.

G. Tertiana lethargica, *Tort.* ib.
Tritæophya carotica, *Sauv.* sp. 7. *Lautter.* 1. 7. 14.
Tertiana apoplectica, *Morton.* Exerc. I. cap. ix. hist. 25.
Tertiana soporosa, *Werlhof.* de febr. p. 6.
Febris epidemica Urbevetana; *Lancis.* de noxiis pal. effluv. I. II. c. 3.

Tertia

The remittent fevers are much more dangerous than the true intermittents, as being generally attended with much greater debility of the nervous system and tendency to putrescency in the fluids than the latter. Sauvages divides his tritæophya, a remittent tertian, into the following species:

1. *Tritæophya syncopalis*, or that attended with fainting. It begins like a tertian, with cold succeeded by heat and profuse sweating; but attended with much more dangerous symptoms, such as cardialgia, enormous vomiting, great weakness, small contracted pulse, coldness of the extremities, and, unless timely assistance be given, kills during the second or third paroxysm.

2. The *causus*, or burning fever of Hippocrates, returns every third day without any new sensation of cold; and is attended with great thirst, heat, but without diarrhœa or sweat, and continues only for one week or two at the utmost. It attacks chiefly young people of a robust and bilious habit of a body, who have been accustomed to much exercise, and exposed to the sun during the heats of summer, and have also used a phlogistic regimen. The tongue is dry, sometimes black; the urine of a red or flame colour; together with pain of the head, anxiety, and sometimes other symptoms still more dangerous.

3. *Tritæophya Vratislaviensis*, was a pestilential disease occasioned by famine, during which the people fed on putrid aliments: the air was infected by the vast number of bodies of those slain in battle, and the inhabitants were also dejected by reason of being deprived of their harvest, and other calamities; to all which was added the continuance of a calm in the atmosphere for a long time. It began with an acute fever, leipyria or coldness of the external parts and a sensation of burning heat inwardly; general weakness; pain of the head and præcordia; serous or bilious diarrhœa; a delirium, in some furious, and accompanied with a dread of being exposed to the air; on the second day the thirst was violent, attended with a bilious vomiting, as well as diarrhœa, tough viscid spitting, fainting, burning heat in the bowels, the tongue dry and seeming as if burnt with a hot iron, a suppression of the voice, anxiety, stupor, after which quickly followed convulsions and death. In some fevers leipyria came on with an exceeding great cold of the extremities, presently followed by an intolerable heat of the viscera, with symptomatic sweats, violent diarrhœa, followed by a very itchy miliary eruption. On the fourth day came on copious sweats, spasms of the lower jaw, nausea, involuntary passing of urine, slight delirium, a flux of ichorous matter from the nostrils, an exceeding tough spitting, an epilepsy, and death. Professor Hahn, who gives

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gives the history of this disease, was himself attacked by it, and suffered in the following manner: On the first day was a violent feverish paroxysm without rigor, a sharp pain in the occiput, and immediately an inflammatory pain over the whole head; the feet were extremely cold, and the extremities rigid with spasms. The pain continued to increase daily to such a degree, that the contact of the air itself became at last intolerable; a dejection of mind and incredible weakness followed; he passed restless nights with continual sweating, heavy and pained eyes, and an universal sensation of rheumatism over the whole body. On the third day the pains were assuaged, but he had a very bad night. On the fourth day all the symptoms were worse, the feet quite chilled, the hands very red and agitated with convulsive motions; he was terrified with apprehensions of death, and had a vomiting every now and then: this day sponges dipped in cold water were applied over the whole body, and he used cold water for his drink. On the eighth day the pulse was convulsive; and the pains were so violent that they made him cry out almost continually. On the ninth day he was delirious, and threw up some grumous blood. On the 11th his pulse was more quiet, and he had a sweat; a decoction of cinchona was given: his voice was broken, his speech interrupted, and his teeth chattered upon one another. On the 12th his jaw was convulsed, he had a risus sardonicus, and deafness; after which the paroxysms returned less frequently, and only towards night. On the 14th he had a chilling cold over the whole body, a cold sweat; frequent lotions were applied, and all the symptoms became milder. On the 18th he had a quick delirium, but fainted as soon as taken out of bed; a sensation of hunger, followed by copious sweats; profound sleep; an aversion from noise; every thing appeared new and extraordinary. On the 36th a cholera; on the 48th a scaling off of the skin, and falling off of the nails. This epidemic carried off above 3000 people at Warsaw. Frequent lotion of the body either cold or tepid, watery glysters, and the copious introduction of watery fluids under the form of drink, were of service. But the most favourable crisis was under the form of some cutaneous eruption.

142 4. *Tritæophya typhodes.* The principal symptom of this fever was a continual sweat with which the patients were almost always wet; with paroxysms returning every third day. Sauvages tells us, that he had twice an opportunity of observing this fever; one was in the teacher of an academy, about 40 years of age, and of a melancholic temperament. He sweated every second night so plentifully, that he was obliged to change his linen nine times; and even on the intermediate days was never perfectly free of fever, and had his skin moistened with sweat. The other was of a woman who went about in man's clothes, and was discovered only after her death. The disease began with a slight sensation of cold, after which she sweated for eight hours. It was attended with the highest debility, anxiety, and at the same time an insatiable hunger.

143 5. *Tritæophya elodes*, was an inflammatory epidemic, but not contagious, terminating about the 13th or 21st day. The disease came on in the night time, with disturbed rest, universal weakness, watchings, great heat and sweat, redness of the face and almost of the whole body, sparkling eyes, the tongue dry and white; a hard, tense, and turgid pulse: about the third day a kind of frenzy frequently came on with the feverish paroxysm, the forerunner of an universal miliary eruption; or, what was worse, with purple spots so close together, that they looked like an erysipelas of the whole body. Sometimes blisters of the size of small pearls, filled with acrid serum, appeared on the neck, armpits, and trunk of the body, which were of all the symptoms the most dangerous. There was a variety of the disease, which Sauvages calls the *humoralis*, and in which the pulse was soft and feeble, with greater weakness over the whole body, and the disposition to sleep more frequent than in the other; the eyes languid; the tongue very white, but not dry; and worms were sometimes discharged.

6. *Tritæophya assodes.* This species arose from a foulness of the primæ viæ, and the effluvia of waters in which hemp had been steeped. It began with rigor, followed by great heats, restlessness, tossing of the limbs, faintings, immoderate thirst, dryness of tongue, delirium, and at length excessive watchings; these last, however, were less dangerous than vertigo or a comatose disposition, which brought on convulsions or apoplexies. 144

7. *Tritæophya carotica.* This had exacerbations every other evening; and its distinguishing symptom was an excessive inclination to sleep, preceded by a severe headach, and followed by delirium, and sometimes convulsions; the tongue was black, and the patient insensible of thirst after the delirium came on. In those cases where the disease proved fatal, a subsultus tendinum and other alarming symptoms, came on. 145

8. *Tritæophya leipyria* is only a variety of the tritæophya causus, already described. 146

9. *Tritæophya deceptiva.* This species at first assumes the appearance of a continued fever; but afterwards degenerates into a remittent, or even an intermittent. It is described by Sydenham, but attended with no remarkable symptoms. 147

10. The last of Sauvages's species of Tritæophya belonging to the remitting tertian is the *Americana.* This, according to Sauvages, is the ardent fever with which the Europeans are usually seized on their first arrival in America, and generally carries off one half of them. Of this there are two varieties, the *very acute* and the *acute*. The very acute ends before the seventh day. It comes on a few days after the person's arrival, with loss of appetite, with dyspnœa and sighing from weakness, headach, lassitude, and pain of the loins: a pyrexia succeeds, with great thirst, sweat, and heat; the sickness increases, nausea comes on, with vomiting of porraceous bile; the tongue rough, the extremities often cold; watching, furious delirium; and the patient frequently dies on the third day. Copious sweats, and a plentiful hæmorrhagy from the nose on the fifth day, but not sooner, are serviceable; but a bilious diarrhœa is the best crisis of all. 148

The acute kind terminates most frequently on the ninth, but very rarely goes beyond the fifteenth day. Death frequently comes on between the fourth and seventh days. It begins with headach, pain in the loins, and sometimes shivering; great lassitude, dyspnœa, Febres. pnœa, thirst; burning fever, increasing every third day; inflation of the abdomen, pain at the pit of the stomach, nausea, and bilious vomiting. Such is the state of the disease within twenty-four hours. The eyes are red, and full of tears; the urine pellucid; there is a low delirium, and continual anxiety; the tongue is dry and red, and sometimes, though rarely, black, which is a still worse sign; the pulse, formerly strong and full, sinks about the fourth day, and becomes tense and spasmodic: if a carus then comes on, the patient dies the fifth or sixth day; but if the pulse keeps up, and no carus comes on, a crisis is to be expected by sweat, by a copious hemorrhagy from the nose, or, which is still more safe, by a bilious diarrhœa, which is never salutary if it comes on before the fifth day.

To the remitting tertian also belong the following species mentioned by Sauvages, viz.

149 1. *Tertiana subcontinua.* This begins like a genuine tertian, and at first hath distinct paroxysms; but these grow gradually more and more obscure, the disease acquiring daily more of the appearance of continued fever, by which it is to be distinguished from the other varieties of this species. It is not unfrequently joined with those symptoms which attend the fatal fever already mentioned; as cardialgia, cholera, syncope, &c. but in a much less degree. The disease commonly begins with little or no sense of cold, but rather a sensation of heat; when the tertian is doubled, it has first a slighter and then a more severe fit; and thus goes on with an exacerbation on the even days: and though it should change from a double into a single tertian, we are still to suspect it, if a weak fit is the forerunner of a very strong one. This change of the tertian into a continued fever is also to be prognosticated if a heat remarkable to the touch is perceived on the day of intermission, together with some disturbance of the pulse, thirst, and dryness of the tongue; all of which show a tendency to inflammation: the same is foretold by the urine being in small quantity, and very red, or of a saffron colour; also an ulcerous or aphthous inflammation of the throat, with difficulty of swallowing, or any very severe symptom coming on in the beginning of the disease, excepting only a delirium, which is easily removed.

150 2. *Quotidiana deceptiva.* This is a disorder of an inflammatory kind, with a strong tendency to putrescency, and sometimes assumes the form of a quotidian. In it the patient frequently complains of cold when he really is hot, and the remission is very indistinct. The disease is known by the great languor of the patient and the foulness of his tongue.

3. *Amphimerina cardiaca* is an acute malignant fever,
151 with daily exacerbations, attended with fainting and vomiting of green bile. Afterwards, the weakness increasing, the patient's extremities grow cold, and a profuse sweat comes on, which is frequently succeeded by death on the fourth day. Another species resembling this Sauvages calls the *syncopalis;* but the cardiaca differs from it in being attended with cardialgia.

4. *Amphimerina paludosa.* This is the fever described
152 by the British physicians under many different names, and appearing under various forms, according to the different constitutions of the patients. This fever in the East Indies, according to Dr Lind of Windsor, generally comes on suddenly, and begins with a sense of debility and a very great lowness of spirits. These symptoms are attended with a greater or less degree of chilliness, vertigo, nausea, very acute pains in the head and loins, and a trembling of the hands; the countenance is pale, the skin commonly very dry and corrugated, the eyes dull and heavy, the pulse quick and small, the breath generally difficult, and interrupted with hiccough.

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As the paroxysm increases, the chilliness now and then gives way to irregular heats, which soon become violent and permanent; the nausea likewise increases; and in some there comes on a vomiting, in which they throw up a great deal of bile. Sometimes bile is likewise voided by stool. The skin grows red; the eyes appear small, and sometimes not a little inflamed. The pulse becomes fuller, and the breath more difficult, attended with great restlessness and a troublesome thirst; notwithstanding which (so great is the nausea) the patient cannot endure any kind of liquids. The tongue becomes foul, and the pain of the head and loins more violent; a delirium then follows; a slight moisture appears on the face, and from thence spreads to the other parts; whilst the violence of the other symptoms abates, and shows the beginning of a remission, which is completed by plentiful sweats.

On the fever's remitting, the pulse returns almost to its natural state; the pains of the head and loins still continue, though somewhat less violent, as likewise the nausea and want of appetite. When the disease gains strength, the remission is scarcely obvious, and is immediately followed by another paroxysm; which begins, not indeed with so great a shivering, but is attended with a greater pain of the head, the greatest anxiety, a heartburn, nausea, vomiting, and bilious stools. The matter most commonly evacuated by vomit and stool is whitish like chalk and water, or curdled milk which is vomited by sucking children, when the curd is much broke down. A heat, immoderate thirst, and delirium now come on. The tongue becomes more foul; the teeth and inside of the lips are covered with a black crust; the breath grows hot and fetid: another remission ensues, attended with a sweat; but this remission is both shorter and less obvious than the first.

This second remission is succeeded by a paroxysm, in which the symptoms are far more violent than in the former; that which the patient discharges by vomiting and purging is more fetid; the mouth, teeth, and inside of the lips, are not only covered with a black crust, but the tongue becomes so dry and stiff, that the patient's voice can scarce be heard. Violent delirium, with restlessness and anxiety, come on chiefly during the paroxysm; nor do these symptoms abate till the fever remits, and the patient sweats.

When the fever becomes so violent, during the third fit, as to end in death, which is often the case, some of the sick have a coma; in others the delirium becomes more violent. The discharges now become more fetid, and have a cadaverous smell; the stools are involuntary; the pulse is so quick, small, and irregular, that it is scarce to be counted, or even felt; a cold sweat is diffused over the whole body, especially the head and neck: the face becomes Hippocratic and convulsed; the patient picks the bed-clothes; a subsultus tendinum comes on; the sick lie constantly on their backs, and insensibly

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insensibly slide down to the foot of the bed; their extremities grow cold; they are then seized with convulsions, with which the scene closes.

In this fever, the urine, which at the beginning is pale, becomes of a deeper colour by degrees, but without depositing any sediment. There seldom or never appear any petechiæ, and the prickly heat which was before on the skin vanishes on the first appearance of the fever. But though these were the general symptoms of this disorder, they varied in the different subjects, and at different seasons of the same year. The pulse, for example, in some, was quick in the beginning of the disorder; in others, it varied with the other symptoms. The skin was generally dry in the beginning of the fit; but in some it was moist, and covered with sweat from the very beginning of the disease. In the month of September, when the disorder raged most, the remissions were very imperfect and obscure; but, on the return of winter and the healthy season, they became more regular, and the disease assumed the appearance of an intermitting fever, to such a degree as at length not to be distinguished from it. In some the remissions could scarce be perceived, and the fever continued for two weeks without any material change for the better or the worse. At this time numbers were seized with it. When the disorder continued for any time without a change, it generally ended in death; while the weather grew better, it sometimes, in the space of a few days, from a common fever became an intermitting one, and the patient recovered, unless his liver, which was sometimes the case, happened to be affected. The cure of an inflammation of the liver proved uncertain and tedious; as it was commonly followed by a colliquative diarrhœa, which generally endangered the patient's life.—Every succeeding paroxysm was observed to be more dangerous than the preceding; the third generally proved fatal; some died during the first. When this happened, the fever, in the language of the country, was called a *puca*, that is a strong fever.

This disease, according to Dr Lind of Haslar hospital, is the autumnal fever of all hot countries, the epidemic disease between the tropics, and the disease most fatal to Europeans in all hot and unhealthy climates. All authors agree that intermittents in general, but particularly this dangerous kind of them, are produced by heat and moisture, but particularly the evaporation of moisture from marshes. Dr Lind of Windsor remarks, that the European seamen are very subject to the fever above mentioned when they happen to arrive at Bengal in autumn. They are predisposed to it from the nature of their food, their confinement on board, the very great heats to which they are exposed during the voyage, and their lying for hours together exposed to the night colds.

Most of the meat used by the crews of those ships is salted, and often in a putrid state, without any fresh vegetables, they having only biscuits, and some other farinaceous matters. The quantity of the vinous or spirituous liquors allowed them is, in his opinion, by far too small to subdue the putrescent disposition of their animal-food. Their fluids consequently become, from day to day, more and more putrescent, and of course more apt to breed and contract this disorder. This disposition is likewise induced by their being stowed very close together, and that for a considerable length of time, and in a foul air, especially when the weather happens to be too stormy to permit the hatches and portholes to be kept open.

Though the heats they endure in the voyage to India are less considerable than those of the country itself, yet they are too much for an European constitution to bear. The general heat at sea within the tropics is about 84° of Fahrenheit's thermometer, which is sufficient to relax them, and promote a corruption of their humours, especially when it coincides with the above causes. It likewise creates a languor and indolence, which alone are sufficient to increase that putrescence. These causes are apt to be considerably aggravated by the men's being often exposed, when on duty, for hours together, to rain, damp, and cold air; a circumstance which frequently happens to them when working their ships up the river Ganges in the night-time. Hence the perspiration is checked, and the excrementitious fluid which used to be discharged by the skin being retained in the body, contributes, he thinks, very much towards the predisposition to this disease.

But the most powerful of all the remote causes is justly thought to be the effluvia of marshes replete with putrid animal-substances. We have not, however, been able to determine from what kind of putrid animal-substances these effluvia derive their virus. For that every kind of putrefaction has not such an effect appears from this, that neither practical anatomists, nor those who by their trades are exposed to the putrid effluvia of animals, for instance such tanners and butchers as keep their shops and stalls very dirty, are more subject than others to putrid diseases. Nor are the ship-stewards and their servants, whose business it is to deliver out the provisions to the ships crews, and who spend the most of their time amongst the putrid and rancid effluvia of the places in which those provisions are kept, more subject to putrid fevers than their ship-mates. But whatever be in this, we are well assured that some particular putrid fermentations produce noxious vapours, which, united with those of marshes, render them more pernicious. Hence evidently proceeds the extreme unhealthfulness of a place called *Culpi*, on the eastern bank of the Ganges. The shores about it are full of mud, and the banks covered with trees. Opposite to the place where the ships lie there is a creek, and about a mile from its entrance stands the town of Culpi: the ships lie about a mile from the shore. None of the sailors on board the ships stationed at this place enjoyed their health. The burying ground also contributed not a little to spread the infection. The ground being marshy, the putrid water flowed from the old graves into the new ones, which infected the grave-diggers and those that attended the funerals; and from this cause many were suddenly seized while they were performing the last duty to their companions. This place has ever been remarkable for the unhealthfulness of its air. It was once customary to send some of the Company's servants here to receive the cargoes of the ships, and send them to Calcutta; but so many of them died on this duty, that the Company was at length obliged to dispense with it.

Hence it plainly appears, how apt putrid animal and vegetable substances are to render the effluvia of fenny

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fenny places more pernicious than they would otherwise be. The reason why great inundations of the Nile and Ganges are followed by a healthy season is, that by this means the putrid animal and vegetable substances dispersed over the contiguous countries are carried off into the sea.—The noxious vapours arising from fens spread but a little way. Dr Lind has often known ships crews at a very little distance from the shore quite free from this disorder. But although these marsh miasmata first bring on the disease, yet contagion particularly spreads it, and renders it more epidemic. Thus the Drake East Indiaman continued free from the disorder for two weeks together, when she had no communication with the other ships; but as soon as the disorder was brought on board, many were seized with it within a few days in such a manner as to leave no room to entertain the least doubt concerning its contagious nature.

Dr Lind of Haslar hospital has given a very curious and learned account of the appearance of this fever throughout the various parts of the globe. It was very common in England in the years 1765 and 1766, one obvious cause of which was the prevalence of the eastern wind. This wind in England is often said to bring with it a fog from the sea; but the truth of the matter is, that in many places of this island the east-wind frequently raises a copious vapour from water, mud, and all marshy or damp places. To this exhaling quality of the eastern wind Dr Lind has often been an eye-witness. When the wind changes to the east, the mud sometimes sends up a vapour as thick as smoke; and the doctor has observed two fish-ponds in his neighbourhood, one of fresh and the other of salt-water, which on the approach of an easterly wind sometimes also emit a dense vapour, as from a pot of boiling water. In order to view this phenomenon distinctly, the person should stand at about 100 yards distance from the mud or ponds. If the sun shines when the wind changes to the east, he will observe a constant steam of vapours arising out of the ponds, from about five to ten yards in height, while the air about him remains serene. As the vapour or fog arising from other bodies glides along the surface of the earth, and is brought by the easterly wind to the ponds, he will still be able, for some time, to distinguish the vapours ascending perpendicularly out of the ponds from those which are carried in an horizontal direction by the wind; especially if the sun continues to shine, though faintly.

This evaporating quality of the east-wind seems to manifest itself also by its effects both on the thermometer and the human body; for a thermometer hung over a damp piece of ground during the fogs or exhalations arising from it, will often indicate a degree of cold below the freezing point. The chilliness of the body, so sensibly perceived when in this situation, seems to proceed from the same cause, and to produce nearly the same sensations, which the damp arising from the wet floor of a chamber communicates to those who happen to be in it.

Winds are not constant in their effects. As we have sometimes warm weather with a north-wind, and sometimes very little heat with one blowing from the south; so the fogs attending an east-wind are not constant, neither is the evaporation above-mentioned at all times to be perceived. It is possible, however, that in all this there may be a deception; and that instead of supposing the quantity of vapours exhaled to be increased by an easterly wind, the coldness of that wind may only condense and render visible the vapours in the air at that time. But even this supposition is liable to great objections, as our coldest north-winds seldom or never produce such an effect, but on the contrary are attended with dry and serene weather.

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Be this as it will, however, an east-wind is usually accompanied with a cold, damp, and unwholesome vapour, which is observed to affect the health both of animals and vegetables, and in many places to produce obstinate intermitting fevers, and also to occasion frequent relapses. In particular spots of the low damp island of Portsea, the ague frequently prevails during the autumnal season, and in some years is much more frequent and violent than in others. It is also observable, that this disease always attacks strangers, or those who have formerly lived on a drier soil, and in a more elevated situation, with greater severity than those who are natives of the island.

The year 1765 was remarkable, not only for the long continuance of the easterly winds, but for an excessive degree of heat, which produced a more violent and general appearance of those diseases than had been known for many years before. In the month of August the quicksilver in Fahrenheit's thermometer often rose to 82° in the middle of the day. This considerable addition of heat, together with the want of refreshing rains, greatly spread the fever, increased its violence, and even changed its form in many places. At Portsmouth, and throughout almost the whole island of Portsea, an alarming continual or remitting fever raged, which extended itself as far as Chichester. At the same time, the town of Gosport, though distant only one mile from Portsmouth, enjoyed an almost total exemption from sickness of every kind; whereas in the neighbouring villages and farm-houses, a mild regular tertian ague affected whole families. The violence of the fever, with its appearances in a continued, remitting, or intermitting form, marked in some measure the nature of the soil. In Portsmouth the symptoms were bad, worse at Kingston, and still more dangerous and violent at a place called *Half-way Houses*; a street so named, about half a mile from Portsmouth, where scarcely end in a family escaped this fever, which generally made its first attack with a delirium. In the large suburb of Portsmouth called the *Common*, it seemed to rage with more violence than in the town, some parts excepted; but even whole streets of this suburb, together with the houses in the dock-yard, escaped its attack.

The marines, who were three times a week exercised early in the morning on South-sea beach, suffered much from the effect of the stagnant water in an adjoining morass. Half a dozen of them were frequently taken ill in their ranks when under arms; some being seized with such a giddiness of their head, that they could scarcely stand; while others fell down speechless, and upon recovering their senses complained of a violent headach. When such patients were received into the hospital, it was observed that some few had a regular ague, but that far the greater number laboured under a remitting fever, in which sometimes indeed there was

Fevers. was no perceptible remission for several days. A constant pain and giddiness of the head were the most inseparable and distressing symptoms of this disease. Some were delirious, and a few vomited up a quantity of bile; but in all the countenance was yellow. A long continuance of the fever produced a dropsy or jaundice, or both. Even a slight attack reduced the most robust constitution to a state of extreme debility; and this weakness, together with the giddiness, continued for a long time after the fever. A scabby eruption now and then made its appearance on the lips and the corners of the mouth: but dry itchy spots over the whole body, resembling much the common itch, and seeming to partake of the nature of that disease, were more frequently observed in the patients at Portsmouth, where there was not the least reason to suspect any infection.

Such is the appearance of the remitting fever occasioned by marsh miasmata in England. In the Netherlands its symptoms are not much different. Dr Lind informs us, that at Middleburg, the capital of West Zealand, a sickness generally reigns towards the latter end of August, or the beginning of September, which is always most violent after hot summers. It commences after the rains which fall in the end of July; the sooner it begins the longer it continues, and it is only checked by the coldness of the weather. Towards the end of August and beginning of September it is a continual burning fever, attended with a vomiting of bile, which is called the *gall-sickness*. This fever, after continuing three or four days, intermits, and assumes the form of a double tertian; leaving the patient in a fortnight, or perhaps sooner. Strangers that have been accustomed to breathe a dry pure air do not recover so quickly. Foreigners in indigent circumstances, such as the Scots and German soldiers, who are garrisoned in the adjacent places, are apt after those fevers to have a swelling in their legs and a dropsy; of which many die.

These diseases, the doctor observes, are the same with the double tertians common within the tropics. Such as are seized with the gall-sickness have at first some flushes of heat over the body, a loss of appetite, a white foul tongue, a yellow tinct in the eyes, and a pale colour of the lips. Such as live well, drink wine, and have warm clothes and good lodgings, do not suffer so much during the sickly season as the poor people; however, these diseases are not infectious, and seldom prove mortal to the natives.

Sir John Pringle observes, that the prevailing epidemic of autumn in all marshy countries, is a fever of an intermitting nature, commonly of a tertian form, but of a bad kind; which, in the dampest places and worst seasons, appears as a double tertian, a remitting, or even an ardent fever. But however these fevers may vary in their appearance according to the constitution of the patient and other circumstances, they are all of a similar nature. For though, in the beginning of the epidemic, when the heat or rather the putrefaction in the air is the greatest, they assume a continued or a remitting form, yet by the end of autumn they usually terminate in regular intermittents.

In Zealand where the air is more corrupted than in other parts of the Netherlands, this distemper is called the *gall-sickness;* and indeed both the redundance and depravation of the bile is sometimes so great, that it has been generally ascribed to the corruption and overflowing of that humour. But though it cannot with justice be said to originate from corrupted bile, it is certain that the disease may be continued, and the symptoms aggravated, by an increased secretion and putrefaction of the bile occasioned by the fever. In proportion to the coolness of the season, to the height and dryness of the ground, this distemper is milder, remits or intermits more freely, and removes further from the nature of a continued fever. The higher ranks of people in general are least liable to the diseases of the marshes; for such countries require dry houses, apartments raised above the ground, moderate exercise, without labour in the sun or evening damps, a just quantity of fermented liquors, plenty of vegetables, and fresh meats. Without such helps, not only strangers, but the natives themselves, are sickly, especially after hot and close summers. The hardiest constitutions are very little excepted more than others; and hence the British in the Netherlands have always been liable to fevers.

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By this distemper the British troops were harassed throughout the whole of the war from 1743 to 1747. It appeared in the month of August 1743; the paroxysms came on in the evening, with great heat, thirst, a violent headach, and often a delirium. These symptoms lasted most of the night, but abated in the morning, with an imperfect sweat, sometimes with a hæmorrhagy from the nose or a looseness. The stomach from the beginning was disordered with a nausea and sense of oppression, frequently with a bilious and offensive vomiting. If evacuations were either neglected, or too sparingly used, the patient fell into a continued fever, and sometimes grew yellow as in a jaundice. When the season was further advanced, this fever was attended with a cough, rheumatic pains, and sizy blood. The officers being better accommodated than the common men, and the cavalry who had cloaks to keep them warm, were not so subject to it; and others who belonged to the army, but lay in quarters, were least of all affected; and the less in proportion to their being little exposed to heats, night-damps, and the other fatigues of the service.

In this manner did the remitting fever infest the army for the remaining years of the war; and that exactly in proportion to their distance from the marshy places, of which we have several notable instances in Pringle's observations. In Hungary the same disease appears with still more violence, and is readily complicated with fevers of a truly pestilential nature, by which means it becomes extremely dangerous. Hungary is acknowledged to be the most sickly climate in Europe, and indeed as bad as any in the world. Here it was where the crusaders in only marching through the country to invade Asia, often lost half their number by sickness; and where the Austrians not long since buried, in a few years, above 40,000 of their best troops, who fell a sacrifice to the malignant disposition of the Hungarian air. The reason of this uncommon malignity is, that Hungary abounds with rivers, which, by often overflowing, leave that low flat country overspread with lakes and ponds of stagnating water, and with large unwholesome marshes. So great is the impurity of these stagnated waters, that by them the rivers, even the Danube, whose course is slow, become in some places corrupted and offensive. The air is moist, Febres. moist, and in summer quite sultry. In the nights of harvest, Kramer tells us, it was so very damp, that the Austrian soldiers could not secure themselves from the moisture even by a triple tent-covering. Here epidemical distempers begin constantly to rage during the hottest months of the year; which are July, August, and September: and these complaints, according to the observations of the physician above mentioned, are the same with those which are epidemic upon the coast of Guinea, and in the sickly climates of the East and West Indies, of which malignant fevers of the remitting and intermitting kind are the most common and dangerous.

The heat of the sun in Hungary is more intense than in any other country of Eurpe; and in proportion to the heat is the pestilential quality of the marshy exhalations. It is constantly observed, that the nearer any city or fort is to a morass or a large river with foul aud oozy banks, the more unhealthy are the inhabitants. At such seasons and places, the air swarms with numberless insects and animalcules, a sure sign of its malignant disposition; and the hotter the summer, the more frequent and mortal are the diseases. In short, this country, on account of its unhealthiness, has been termed *the grave of the Germans;* and in Italy, the Campania of Rome is almost equally unhealthy. Lancisius, physician to Pope Clement XI. furnishes us with a very striking instance of the malignant quality of the air of Campania. Thirty gentlemen and ladies of the first rank in Rome having made an excursion, upon a party of pleasure, towards the mouth of the Tyber, the wind suddenly shifting, blew from the south over the putrid marshes, when 29 were immediately seized with a tertian fever, only one escaping.

The island of Sardinia is annually visited with an epidemical sickness, which rages from June to September, and is called by the natives the *intemperies.* In some years there is a want of rain for four or five months; and then it is that this sickness exerts its utmost violence, being always more fatal in some places than in others, and in particular to strangers. Of this the British had a severe proof in 1758.—Admiral Broderick, in the Prince ship of war, anchored in the bay of Oristagni, where 27 of his men, sent ashore on duty, were seized with the epidemical distemper of this island; twelve of them in particular, who had slept on shore, were brought on board delirious. All of them in general laboured under a low fever, attended with great oppression at the breast and at the pit of the stomach, a constant retching, and sometimes a vomiting of bile; upon which a delirium often ensued. These fevers changed into double tertians, and terminated in obstinate quartan agues. It is worthy of remark, that in this ship, which lay only two miles from the land, none were taken ill but such as had been on shore, of whom seven died. The prior of a convent, making a visit to the English officers, informed them, that the intemperies of the island were a remitting or intermitting fever, and that he himself had suffered several attacks of it. Sardinia was formerly so remarkable for its unwholesome air, that the Romans used to banish their criminals thither; and it is at present but thinly peopled, owing to the mortality occasioned by this annual sickness. For although it is about 140 miles long, and in several places 75 miles broad, yet it is computed that the whole number of its inhabitants does not exceed 250,000: an inconsiderable number, when compared with the inhabitants of the lesser, but comparatively more healthful, island of Corsica; though even there the French lost a number of their troops by intermitting and remitting fevers. In the island of Minorca, too, Dr Cleghorn informs us, that fevers of this kind prevail exceedingly; that their types are various, their symptoms violent, the intermissions fallacious, and that they frequently and suddenly prove fatal. It is more than probable, he adds, from the accounts of several physicians and travellers, that epidemical tertians are not wholly confined to the coasts and islands of the Mediterranean, but that they are equally frequent and destructive in many other parts of the globe; and perhaps may be deemed the anniversary autumnal distempers of most hot countries in the world. And though in the mild climate of Britain, a tertian may easily be cured when it is discovered; yet in warm climates, such is the rapid progress of the distemper, that it is necessary to know it in the very beginning, which is very difficult for those who have never seen any but the tertians usually met with in Britain.

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From Dr Cleghorn's account of Minorca, however, it doth not appear why that island shonld be so much infested with fevers of this kind, since it is far from being a marshy country; nay, on the contrary, is very dry. The south wind, he observes, is very unhealthy; and it is the prevalence of this wind which brings on the fever: but still the difficulty is not removed, because the sea air is so far from bringing on such dangerous diseases, that it is one of the greatest preservatives against them. As to the moisture which must necessarily accompany an insular situation, that cannot reasonably be admitted as a cause of this or any other disease. In the London Medical Observations we find a paper on a subject very similar to the present, namely, the mischiefs produced by lying in damp sheets, or being exposed to moist vapour. The author tells us, that he hardly knows a distemper the origin of which has not by some been ascribed to lying in a damp bed, or sitting in a wet room; and yet he does not know any one which will certainly be produced by these causes, and people frequently expose themselves to such causes without suffering any ill effects. "It must be owned indeed, (says he), that the vapours arising from the bilge-water of ships tend to produce a scurvy. The swampy plains also near the mouths of great rivers which are often overflowed, and low grounds which cannot readily be drained, and those tracts of land where the thickness and extent of the woods keep the ground moist and half putrid for want of ventilation, are destructive to the neighbouring inhabitants, by occasioning obstinate intermittents in the colder climates, and pestilential fevers in the hotter regions. But all this mischief arises not merely from moisture, but from an unventilated and putrid moisture; for the inoffensiveness of mere wetness, untainted with putridity, may be reasonably inferred from the following considerations. The air is often fully saturated with moisture; and yet neither is any epidemical distemper produced by it, nor are those remarkably aggravated with which the sick happen at that time to be afflicted. The air from rivers and from the sea is probably more replenish-

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Fevers. ed with vapours than inland countries cleared of their woods: yet the most celebrated of the ancient physicians recommended the bank of a running river for the situation of a house, on account of its peculiar healthfulness; and many invalids are sent by the modern physicians to the sea side, only for the benefit of the sea air.

"Where the sailors are cleanly, and not too much crowded, they are often as healthy during long voyages at sea, as they would have been on any part of the land. Venice is not observed to be less healthy than London or Paris.

"Those who are much disposed to sweat, lie many hours in bedclothes impregnated probably with a less wholesome moisture than would have been left in the sheets half-dried after washing; and there is no reason to think that any remarkable injury was done to the health by the continuance of such sweats almost every night for weeks, and for months, except what arose from the too great copiousness of this evacuation.

"Children, and such as are troubled with the stone, and those who, from other infirmities or age, constantly wet their beds with their urine, do not appear to suffer in their health on this account.

"It is a common practice, in some disorders, to go to bed with the legs or arms wrapped in linen cloths thoroughly soaked in Malvern water, so that the sheets will be in many places as wet as they can be; and I have known these patients and their bedfellows receive no harm from a continuance of this practice for many months. Nor can it be said that the Malvern water is more innocent than any other water might be, on account of any ingredients with which it is impregnated; for the Malvern water is purer than that of any other spring in England which I ever examined.

"The greatest valetudinarians do not scruple to sprinkle lavender-water upon their sheets; and yet, when the spirit is flown off, there is left what is as truly water as if it had been taken from the river.

"Is it observed, that laundresses are peculiarly unhealthy above other women, though they live half their time in the midst of wet linen, in an air fully saturated with vapours? Many other employments might be mentioned, the persons occupied in which are constantly exposed to wet floors or pavements, or to be surrounded with watery vapours, or to have their clothes often wet for many hours together.

"Is it the coldness of wet linen which is to be feared? But shirts and sheets, colder than any unfrozen water can be, are safely worn and lain in by many persons, who, during a hard frost, neither warm their shirts nor their sheets.—Or does the danger lie in the dampness? But then, how comes it to pass, that a warm or cold bath, and long-continued fomentations, can be used, without the destruction of those who use them? Or is it from both together? Yet we have long heard of the thickness and continuance of the cold fogs in the seas north-west of England, but have never yet been told of any certain ill effect which they have upon those that live in these countries."

With regard to the causes of fevers, however, Dr Lind is of opinion, that noxious vapours arising from the earth are for the most part to be blamed. Even in countries seemingly dry, and where violent rains are not frequent, he thinks the air may load itself with putrid exhalations from the ground; and that, except in the burning deserts of Arabia or Africa, people are nowhere exempt from diseases occasioned by putrid moisture. In most of the hot countries the pernicious effects of the putrid vapours are by no means equivocal. In Guinea, they seem to be more extraordinary than anywhere else in the world; neither indeed can it be supposed, that a hot and moist atmosphere can be without putrescency. It may in general be remarked, that in sultry climates, or during hot weather, in all places subject to great rains, where the country is not cleared and cultivated, but is overrun with thickets, shrubs, or woods, especially if there are marshes or stagnating waters in the neighbourhood, sickness may be dreaded, and particularly the remitting fever of which we now treat. The fens, even in different counties of England, are known to be very prejudicial to the health of those who live near them, and still more so to strangers; but the woody and marshy lands in hot countries are much more pernicious to the health of Europeans. In all those unhealthy places, particularly during fogs or rains, a raw vapour, disagreeable to the smell, arises from the earth, and especially in the huts or houses. But of all the vapours which infest the torrid zone, the most malignant and fatal are *harmattans*: They are said to arise from the conflux of several rivers in the king of *Dormeo's* dominions at Benin (the most unwholesome part of Guinea), where travellers are obliged to be carried on men's backs for several days journey, through swampy grounds, and over marshes, amidst stinking ooze, and thickets of mangrove trees which are annually overflown. These vapours come up the coast to a surprising distance, with the south-east and north-east winds: and it has been observed, that in their progress they have often changed both the course of the winds and of the sea-currents. The times of their appearance at Cape Coast are the months of December, January, or February. The north-east and south-east winds are always unhealthy, but particularly so during the harmattan season. In some years this vapour is scarce perceptible; but in others it is thick, noxious, and destructive to the blacks as well as whites.—The mortality is in proportion to the density and duration of the fog. It has a raw putrid smell; and is sometimes so thick, that a person or house cannot be discerned through it at the distance of 15 or 20 yards: and it continues so for 10 or 14 days; during which it opens the seams of ships, splits or opens the crevices of wood as if shrunk or dried with a great fire, and destroys both man and beast.—In the year 1754 or 1755, the mortality occasioned in Guinea by this stinking fog was so great, that in several negro towns the living were scarce sufficient to bury the dead.—Twenty women brought from Holland by a new governor to the Castle *del Mina*, perished, together with most of the men in the garrison. The gates of Cape Coast castle were shut up for want of centinels to do duty; the blacks dying at this time as well as the white people. It is lucky that it is only in some years that *harmattans* are so very thick and noxious, otherwise that part of the country would be depopulated. It is observed that all fogs are extremely unhealthy in those parts, particularly before and after the rainy seasons; but the above account of the *harmattans* appeared so very extraordinary and incredible to some of Dr Lind's readers, that he thought proper to publish

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publish a further corroboration of the facts above mentioned. "A gentleman (says he) who had long resided at Cape Coast castle, informed me, that during the time of this fog, being in the upper chambers of the fort, the boards of the floor shrunk so much, that he could discern the candles burning in the apartments below him (there are no plaster ceilings used in those hot countries), and that he could then even distinguish what people were doing in the apartments below; the seams of the floor having opened above half an inch while the fog lasted, which afterwards, upon its being dispelled, became close and tight as before."

In Africa the rains and dews seem to be possessed of qualities almost equally pernicious with the fogs. This much is certain, that in Guinea, many of the principal negroes, and especially of the mulatto Portuguese, take the utmost precaution to avoid being wet with those rains, especially such as fall first. At the setting in of the rainy season, they generally shut themselves up in a close well-thatched hut, where they keep a constant fire, smoke tobacco, and drink brandy, as preservatives against the noxious quality of the air at that time. When wet by accident with the rain, they immediately plunge themselves into salt water, if near it. Those natives generally bathe once a-day, but never in the fresh water rivers when they are overflown with the rains: at such times they prefer for that purpose the water of springs. The first rains which fall in Guinea are commonly supposed to be the most unhealthy. They have been known, in 48 hours, to render the leather of the shoes quite mouldy and rotten, they stain clothes more than any other rain; and soon after their commencement, even places formerly dry and parched swarm with frogs. At this time skins, part of the traffic of Senegal, quickly generate large worms; and it is remarked, that the fowls, which greedily prey on other insects, refuse to feed on these. It has been farther observed, that woollen cloths wet in those rains, and afterwards hung up to dry in the sun, have sometimes become full of maggots in a few hours.—It is also probable, that as in some of those countries the earth, for six or eight months of the year, receives no moisture from the heavens but what falls in dews, which every night renew the vegetation, the surface of the ground in many places becomes hard and incrustated with a dry scurf, which pens up the vapours below; until, by the continuance of the rains for some time, this crust is softened, and the long pent up vapours set free. That these dews do not penetrate deep into the earth is evident from the constant dryness and hardness of such spots of ground in those countries as are not covered with grass and other vegetables. Thus the large rivers in the dry season being confined within narrow bounds, leave a great part of their channel uncovered, which having its moisture totally exhaled, becomes a solid hard crust; but no sooner the rains fall than by degrees this long parched up crust of earth and clay gradually softens, and the ground, which before had not the least smell, begins to emit a stench, which in four or five weeks becomes exceedingly noisome, at which time the sickness is generally most violent.

This sickness, however, is not different from the remitting fever which has been described under so many various forms and names. An inflammatory fever is seldom observed, during the season of sickness, in this part of the world; and we shall conclude our description of the *amphimerina paludosa* with some extracts from the surgeon's journal in a ship that sailed up the rivers of Guinea.

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"On the 5th of April we sailed up the river of Gambia, and found all the English in the fort in perfect health. The surgeons of the factory informed me, that a relaxation of the stomach, and consequently a weakened digestion, seemed to bring on most of the diseases so fatal to Europeans in the sickly season. They were generally of a bilious nature, attended with a low fever, sometimes of a malignant, at other times of a remitting kind.—On the 12th of April, after sailing 30 miles up the river St Domingo, we came to Catchou, a town belonging to the Portuguese in Lat. 20° N. In this town were only four white people, the governor, and three friars. The number of whites in the trading ships was 51. One morning towards the latter end of April, a little rain fell. On the 13th of May there was a second shower, accompanied with a tornado. On the 18th of May it rained the whole day; and the rain continued, but with short intervals, until the beginning of October.

"In the month of June almost two-thirds of the white people were taken ill. Their sickness could not be well characterised by any denomination commonly applied to fevers: it however approached nearest to what is called a *nervous fever*, as the pulse was always low, and the brain and nerves seemed principally affected. It had also a tendency to frequent remissions. It began sometimes with a vomiting, but oftener with a delirium. Its attack was commonly in the night; and the patients, being then delirious, were apt to run into the open air. I observed them frequently recover their senses for a short time, by means of the heavy rain which fell upon their naked bodies. But the delirium soon returned: they afterwards became comatose, their pulse sunk, and a train of nervous symptoms followed; their skin often became yellow; bilious vomitings and stools were frequent symptoms. The fever reduced the patient's strength so much, that it was generally six weeks or two months before he was able to walk abroad. A consuming flux, a jaundice, a dropsy or obstructions in the bowels, were the consequences of it. Of 51 white men, being the companies of four ships which were at Catchou, one-third died of the fever, and one-third more of the flux, and other diseases consequent upon it; and of these not one was taken ill till the rains began.

"I believe, on the whole face of the earth, there is hardly to be found a more unhealthy country than this during the rainy season: and the idea I then conceived of our white people was by making a comparison of their breathing such a noxious air, with a number of river-fish put into stagnating water; where, as the water corrupts, the fish grow less lively, they droop, pine away, and many die.

"Thus some persons became dull, inactive, slightly delirious, at intervals; and, without being so much as confined to their beds, they expired in that delirious and comatose state in less than 48 hours after being in apparent good health. The white people in general became yellow; their stomach could not receive much food without loathing and retchings. Indeed it is no wonder that this sickness proved so fatal, that recoveries

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ries from it were so tedious, and that they were attended with fluxes, dropsies, the jaundice, ague-cakes, and other dangerous chronical distempers. It seems more wonderful to me that any white people ever recover, while they continue to breathe so pestiferous an air as that at Catchou during the rainy season. We were, as I have already observed, 30 miles from the sea, in a country altogether uncultivated, overflowed with water, surrounded with thick impenetrable woods, and overrun with slime. The air was vitiated, noisome, and thick; insomuch that the lighted torches or candles burnt dim, and seemed ready to be extinguished: even the human voice lost its natural tone. The smell of the ground and of the houses was raw and offensive; but the vapour arising from putrid water in the ditches was much worse. All this, however, seemed tolerable, when compared with the infinite numbers of insects swarming every where, both on the ground and in the air; which, as they seemed to be produced and cherished by the putrefaction of the atmosphere, so they contributed greatly to increase its impurity. The wild bees from the woods, together with millions of ants, overran and destroyed the furniture of the houses; at the same time, swarms of cockroaches often darkened the air, and extinguished even candles in their flight; but the greatest plague was the musquettoes and sand-flies, whose incessant buzz and painful stings were more insupportable than any symptom of the fever. Besides all these, an incredible number of frogs on the banks of the river made such a constant and disagreeable croaking, that nothing but being accustomed to such an hideous noise could permit the enjoyment of natural sleep. In the beginning of October, as the rains abated, the weather became very hot; the woods were covered with abundance of dead frogs, and other vermin, left by the recess of the river; all the mangroves and shrubs were likewise overspread with stinking slime."

After so particular a description of the remitting fever in many different parts of the world, we presume it will be needless to take notice of any little varieties which may occur in the warm parts of America, as both the nature and cure of the distemper are radically the same: neither shall we lengthen out this article with further descriptions of remitting fevers from the works of foreign authors, as, from what we have already said, their nature cannot easily be mistaken.

Cure. The great difficulty in the cure of remitting fevers arises from their not being simple diseases, but a complication of several. Fevers, properly speaking, have but three or four different appearances which they can assume without a complication. One is, when they are attended with a phlogistic diathesis; another is, when they assume the form of genuine intermittents; a third is, when they produce a great debility of the nervous system; and the fourth is, when along with this debility there is also a rapid tendency to putrefaction. If, therefore, all these species happen to make an attack at once, the most dangerous fever we can imagine will be produced; and however contrary it may be to our theories to admit the possibility of such an attack, the truth of the fact is too often confirmed by fatal experience. In the beginning of remittent fevers, for instance, the symptoms indicate a high degree of inflammation: but if the practitioner attempts to remove this inflammation by blood-letting or other evacuations, the pulse sinks irrecoverably, and the person dies with such symptoms as show that the nervous system has been from the beginning greatly affected; at the same time the high stimulants and cordials, or cinchona, which would have conquered the nervous part of the disease, increase the inflammatory part of it to such a degree, that, by a too early exhibition of them, the patient also dies, but after another manner.

In the remitting fever of the East Indies, Dr Lind of Windsor formed the following indications of cure. 1. To allay the violence of the fever. 2. To evacuate the putrid humours, and take great care to prevent the body from inclining to putrefaction. 3. To keep up the strength of the patient as much as possible during the disorder. 4. To lose no time in preventing the return of the paroxysms.

To allay the violence of the fever, every thing that can contribute to increase it ought to be carefully avoided or removed; such as great heat, too strong a light falling on the eyes, noise, and motion. If during the paroxysm the head and loins be affected with violent pains, the pulse be full and hard, and the heat intense, bleeding may be used, but with the greatest caution: for, however useful this operation may be in cold climates, the success of it in warm ones is so far from being certain, that the lives of the patients have been often very much endangered, nay even destroyed by it. Dr Badenoch, and the surgeon of the Ponsborne, endeavoured each of them to relieve two patients by blood-letting; and the consequence was, that each of them lost one patient. Dr Lind bled two patients; one of whom was Mr Richardson, the first mate of the ship, who complained of a most violent pain in his head, with a full hard pulse. About four or five ounces of blood were taken from him, by which he was greatly relieved: nor was the cure retarded by it; nay, the fever afterwards became less irregular. At the time the other patient was bled, the disease was exceedingly frequent and violent. He was so earnest for bleeding, that he fired all the rest with the same desire, swearing, that by refusing them this only remedy, every one of them would be sent to their graves. To quiet them, therefore, and get quit of their importunities, the doctor complied with their request, and took about five or six ounces from him who had been the first to require it. The consequence was, that he immediately lost his strength; and in less than an hour, during which time he made his will, was carried off by the next fit. It is necessary, however, to observe, and indeed the doctor himself makes the observation, with regard to this patient, that he was bled at an improper time, namely, between the fits; whereas, had he been bled in the hot fit, it is possible he might have been relieved.

In support of the advantages to be derived from bleeding under proper circumstances, we have the authority both of Cleghorn and Pringle. As Dr Cleghorn practised in a very hot country, his observations must in the present case have greater weight than those of Pringle, who practised in a colder one. The former acquaints us, that if he was called in early enough, unless there was a strong contra-indication, he always used to take away some blood from people

Febres. people of all ages; namely, from robust adults, ten or twelve ounces; from others a smaller quantity, in proportion to their strength and years. And further, if a violent headach, obstinate delirium, and heat or pains of the bowels, were urgent, the bleeding was repeated within a day or two. By this seasonable evacuation, he found the vehemence of all the paroxysms somewhat diminished; the apyrexia became more complete; the operation of emetics and cathartics rendered safer and more successful; and the terrible symptoms which happened about the height of the distemper, such as raving *sopor*, difficulty of breathing, inflammations of the abdominal viscera, &c. were either prevented or mitigated. But if the fever had continued for some time before he was called, and the mass of blood appeared to be too much melted down or inclined to a putrid dissolution, he either abstained from bleeding entirely, or took away a very small quantity, though some urgent symptoms might seem to require a larger evacuation. As to the time of performing the operation, he acquaints us, that it is safe enough, except when the cold fit lasts or is soon expected, or while the skin is covered with critical sweats; and that he usually opened a vein in the beginning of the hot fit; by which means the sick were relieved, the immoderate heat of the body, which is often productive of fatal effects, was diminished, and the critical sweats brought on sooner and in greater abundance.

But though Dr Lind found venesection to be of such pernicious tendency in his patients, cooling acidulated liquors were of the utmost service, as they corrected the putrid humours, lessened the heat and thirst, and of course prevented the fever from arriving at so great an height as it would otherwise have done. Those cooling liquors are the best which are made up with some farinaceous substance, as they most easily unite with other fluids. Fossil acids too, and crystals of tartar, especially the latter, are of considerable use, not only in this, but in other fevers. The neutral salts, prepared with the juice of lemons, were likewise given with success during the heat of the fever. They lessen the nausea, the fits become more regular, and the remissions more full; and they are particularly grateful when given in a state of effervescence. The good effects of these draughts we are in a great measure to ascribe to the antiseptic quality of the fixed air extricated from them during the effervescence.

During the remission, it is proper to evacuate the putrid humours, by small doses of ipecacuanha, or rather tartar emetic. The tartar emetic indeed appears to be endowed with some kind of febrifuge virtue, which Dr Cullen thinks is owing to its relaxing the febrile spasm taking place in the capillary vessels. But should there appear any symptoms of a topical inflammation in some of the abdominal viscera, a thing which never happens unless the disorder has been of some standing, vomiting is to be avoided, and we are to depend upon purgatives alone for the evacuation of the putrid bile. These are always useful in the cure of this disorder. But all acrid and strong purgatives are to be carefully avoided, and only the mild antiseptic ones made use of, such as crystals of tartar, or tamarinds made up with manna or with Glauber's salt.

Tertian. Though in these diseases there is a great quantity of putrescent bile collected in the body, yet it seems much more probable that this is the *effect* than the *cause* of the disorder; and therefore, though we carry off the quantity collected ever so often, more of the same kind will still be produced by the putrescent disposition of the other fluids, at the same time that the strength of the patient must necessarily be diminished by repeated evacuations, when it ought rather to be kept up by all possible means. We ought well to observe, however, that the mineral acids have not that property of sweetening putrid bile which the vegetable ones have: and therefore the same relief will not be given by them which might reasonably be expected from vinegar or lemon juice.

In order to keep up the strength of the patient, good food is absolutely necessary. Dr Lind allowed the sick small messes of panada made with boiled rice and barley mixed with currants or raisins and prunes, seasoned with sugar and a little wine, especially claret. During the paroxysms, they had gruel made of flour and rice, with sugar and the juice of acid fruit; and when the fit went off, a little wine was added to this mixture.

The shirts and bedding must be very often changed and well aired; their stools, and all filth and nastiness, are to be immediately removed; the places where they are lodged should be well aired and frequently sprinkled with vinegar; and, in the last place, the sick must be exceedingly well nursed. Blisters, according to Dr Lind, should never be used till the fever has been of long continuance, or the spirits and pulse of the patient have begun to flag. But here our author has implicitly followed Dr Huxham, whose theory concerning the use of blisters is now found to be erroneous. According to that celebrated author, blisters are capable of doing considerable hurt in all cases where there is a tendency to inflammation, by increasing the motion of the fluids and the oscillatory power of the vessels, both of which are already too great. They are also improper, according to him, when there is a considerable tendency of the fluids to putrefaction; because he supposes the salts of these flies to operate in the same manner with volatile alkalies, that is, by dissolving and putrefying the blood still farther. But Sir John Pringle has shown, that, in inflammatory fevers as well as those of the putrid kind, both blisters and volatile salts may be of service; the latter, particularly, he hath experimentally proved to be so far from promoting putrefaction, that they are exceedingly strong antiseptics.

In the East Indies, Dr Lind found it absolutely necessary to exhibit the Peruvian bark in large quantities, and as early as possible. By this method he not only secured the patient from the imminent danger of death to which he was exposed at every fit, but likewise conquered those obstructions which were apt to ensue in the abdominal viscera, and which are to be attributed to the continuance of the disorder, and not to the bark employed to cure it. He always gave the cinchona during the second remission, as all his care was during the first to cleanse the primæ viæ. He observes, however, that it is to no purpose to give the bark till the necessary purgations are over; but assures us, that it never fails, unless from the coming on of a vomiting or

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or diarrhœa it cannot be taken in sufficient quantities before the return of a paroxysm. To prevent the medicine from vomiting or purging, he mixed a few drops of liquid laudanum with every dose of it. Half a dram was given every half hour in some convenient vehicle, beginning as soon as the fever had considerably abated, and the pulse was returned nearly to its natural state; both which generally happened before the sweats were over. An ounce of the bark was sometimes found too little to check the fever, but an ounce and a half never failed. It must be continued daily in small doses till the patient has recovered his strength, and then a greater quantity must be given, especially at the season when the rivers overflow the country.

Dr Pringle found the autumnal remittents in the Netherlands complicated with a great many inflammatory symptoms; for which reason it was generally found necessary to open a vein in the beginning. The vernal and later autumnal remitting fevers are accompanied with pleuritic and rheumatic pains from the coldness of the weather, and on that account require more bleeding. A physician unacquainted with the nature of the disease, and attending chiefly to the paroxysms and remissions, would be apt to omit this evacuation entirely, and give the cinchona too soon, which would bring on a continued inflammatory fever. In these countries a vein may be safely opened either during the remission or in the height of a paroxysm; and our author also found good effects resulting from bleeding in the hot fits of the marsh fever, even after it had almost come to regular intermissions. After bleeding, a purgative was usually exhibited, of which he gives us the following formula.

℞. Infusi senæ commun. ℥iij.
Elect. Lenitiv. ℥ss.
Nitr. pur. ʒi.
Tinct. sen. ʒvi. M.

Of this only one half was taken at once; and if it did not operate twice in four hours, the remainder was then taken. This potion agreed with the stomach, purged plentifully, and therefore was a very useful composition. Next morning, when there was almost always some remission, he gave one grain of emetic tartar rubbed with 12 grains of crabs-eyes, and repeated the dose in two hours, if the first had little or no effect; or at any rate in four hours. This medicine was intended not only to vomit, but also to operate by stool, and excite a sweat. If these evacuations were procured, the fever generally became easier, and was even sometimes cured. This he prefers to the ipecacuanha, and therefore in the latter years of his practice disused that root entirely. The same medicine was repeated next day or the day following; or if not, a laxative clyster was thrown up: and this method was continued till the fever either went off altogether, or intermitted in such a manner as to be cured by the cinchona.

A similar method was followed by Dr Huck in the remitting fevers of the West Indies and North America. In the beginning he let blood; and in the first remission gave four or five grains of ipecacuanha, with from half a grain to two grains of emetic tartar. This powder he repeated in two hours, taking care that the patient should not drink before the second dose; for then the medicine more readily passed into the bowels after it had operated by vomiting. If, after two hours more, the operation either way was small, he gave a third dose, which commonly had a good effect in opening the first passages; and then the fever either went quite off, or intermitted in such a manner as to yield to the bark. On the continent, he found little difficulty after the intermission; but in the West Indies, unless he gave the cinchona upon the very first intermission, though imperfect, the fever was apt to assume a continued and dangerous form.

In the remitting fevers of hot countries, however, it must be observed, that the lancet must in all cases be much more sparingly used than in similar diseases of the colder regions; and we must also be sparing of venesection in those countries where the marsh effluvia are very strong and prevail much. For this reason Dr Lind of Haslar greatly condemns the practice of indiscriminate bleeding when people first arrive in hot climates. The first diseases indeed which occur in a voyage to the southward are, for the most part, of an inflammatory nature, and owing to a sudden transition from cold to hot weather. This occasions a fulness and distention of the vessels; whence all Europeans, on their first arrival under the tropic, bear evacuations much better than afterwards. The practice of indiscriminately bleeding, however, a number of the ship's company when they first come into a warm latitude, is by no means found to answer the purpose of a preventive. In such cases, indeed, as plainly indicate a plethoric disposition brought on by the heat, blood-letting is certainly useful. The signs of this are a pain and giddiness in the head; a heaviness and dulness of the eyes, which sometimes appear slightly inflamed: there is also commonly a sense of weight and fulness in the breast, the pulse at the same time being quick and oppressed.

But the case is quite different after a longer continuance of sultry weather, and when the constitution is in some measure habituated to the hot climate. For it is then observed, that the symptoms of inflammations in the bowels, even the most dangerous, are not near so severe in such climates as in cold countries; nor can the patients bear such large evacuations. The physician, however, must take care not to be misled by the apparent mildness of the symptoms; for he will find, notwithstanding such deceitful appearances, that the inflammation makes a more rapid progress in hot countries than in cold, suppurations and mortifications being much more suddenly formed; and that in general all acute distempers come sooner to a crisis in the warm than in colder regions. Hence it is an important rule of practice in those climates, to seize the most early opportunity, in the commencement of all threatening inflammations, to make frequent though not copious evacuations by blood-letting. For by delay the inflammation quickly passes from its first to its last or fatal stage; at least, an imperfect crisis in such inflammatory fevers ensues, which fixes an obstruction in the viscera extremely difficult to remove.

It is indeed a general maxim with some physicians in the West Indies, that in most acute distempers bleeding in that country is prejudicial. This is founded upon a supposition that the crassamentum of the blood is

Febres. is thinned, and the solids greatly weakened, by the heat of the climate. It is therefore objected, that bleeding in such an habit of body weakens the powers of nature, and withdraws the strength which is requisite to support the patient until the crisis of the fever.

This reasoning is partly just; but, like all general maxims, will admit of exceptions. First, with regard to sailors, it is to be remembered, that they are more exposed to quick vicissitudes of heat, cold, damps, and to various changes of the air and weather, than most of the other inhabitants of the Torrid Zone. Add to this, that their intemperance, and the excesses they are apt to fall into whenever it is in their power to commit them, render them more liable to inflammations than any other set of people. Hence their diseases require more plentiful evacuations than the land-inhabitants of those parts of the world, and generally they bear them better. But with regard to the natives of the country, or those who have remained long there, it must be proper to bleed them very sparingly, making allowance for the different seasons of the year, the temperature of the air, and the situation of the places where they reside. Thus, in some parts, even on the island of Jamaica, at particular seasons, the weather is cool; wherefore, in these places, and at such seasons, the inhabitants having their fibres more rigid, and a firmer crasis of their blood, bear venesection much better.

In cold countries the state of the air greatly assists in restoring the impaired spring of the fibres; whereas every thing almost in warm weather, such as heat, moisture, &c. concur to relax and weaken the habit of body. Thus we may daily see persons in Britain, after having suffered a most severe fit of sickness, recover their strength and spirits in a few days, and in a very short time their natural constitution. But the case is very different in the sultry regions of the Torrid Zone, or indeed in any part of the world where the heat of the season causes the mercury to stand for any length of time at the 77th degree and upward of Fahrenheit's thermometer. During such an excess of heat, debility after fevers is apt to remain with European constitutions for several months. In Jamaica, the convalescents are sent to the cool summits of the mountains; but a retreat to a more northern climate is often absolutely necessary to recover their wonted tone and vigour of body. It is a well-established observation, that the negroes and aborigines of the Torrid Zone cannot bear plentiful evacuations by the lancet. They commonly mix the most stimulating poignant spices with their ordinary light food, and this is found by experience suitable to their constitutions.

As proper preventives for the dangerous fevers of which we are treating, Dr Lind on all occasions recommends the avoiding of stagnant water, or putrid marshes; the use of proper food, cleanliness, and sobriety. Of the propriety of removing from the neighbourhood of those places whose pestilential effluvia produce the disorders, we cannot possibly entertain a doubt; and of the efficacy of proper food in preventing putrid disorders he gives a remarkable instance in the Sheerness man of war, bound to the East Indies. As they went out, the men being apprehensive of sickness in so long a voyage, petitioned the captain not to oblige them to take up their salt provisions, but rather to permit them to live upon the other species of their allowance. It was therefore ordered, that they should be served with salt-meat only once a-week; and the consequence was, that after a passage of five months and one day, the ship arrived at the Cape of Good Hope without having a single person sick on board. As the use of Sutton's pipes had been then newly introduced into the king's ships, the captain was willing to ascribe part of such an uncommon healthfulness to their beneficial effects; but it was soon discovered, that, by the neglect of the carpenter, the cock of the pipes had all this while been kept shut. This ship remained in India some months, where none of the men, except the boats crew, had the benefit of going on shore; notwithstanding which, the crew continued to enjoy the most perfect state of health; they were, however, well supplied with fresh meat. On leaving India, knowing they were to stop at the Cape of Good Hope, and trusting to a quick passage, and the abundance of refreshments to be had there, they ate their full allowance of salt meats, during a passage of only 10 weeks; and it is to be remarked the air-pipes were now opened. The effect of this was, that when they arrived at the Cape, 20 of them were afflicted in a most miserable manner with scorbutic and other disorders. These, however, were speedily recovered by the refreshments they met with on shore. Being now thoroughly sensible of the beneficial effects of eating, in these southern climates, as little salt meat as possible when at sea, they unanimously agreed, in their voyage home from the Cape, to refrain from their too plentiful allowance of salt flesh. And thus the Sheerness arrived at Spithead, with her full complement of 160 men in perfect health and with unbroken constitutions, having in this voyage of 14 months and 15 days buried but one man, who died in a mercurial salivation.

Tertian. Thus we see, that a free and pure air is not a sufficient preservative against a putrescent state of the fluids, without proper food; and, on the other hand, we have a very remarkable instance of the inefficacy of the most salutary food to prevent putrid diseases, in a very noxious state of the atmosphere. In the year 1717, at the siege of Belgrade in Hungary, the fever of the country, and the flux, occasioned a most extraordinary mortality among the troops. The dread of these diseases caused every one, as may naturally be supposed, to have recourse to different precautions for self-preservation. Prince Eugene, the commander in chief, had water and the provisions for his table sent him twice a week from Vienna. The pure stream of the river Kahlenberg was regularly brought to him: he avoided all excesses, and lived regularly or rather abstemiously; refreshed himself often by eating a cool melon; and mixed his usual wine, which was Burgundy, with water. Yet, notwithstanding his utmost care, he was seized with a dysentery; which would have quickly put an end to his life, had not the speedy conclusion of that campaign permitted him to make a quick retreat.

At this unhealthy season, when hardly one imperial officer, much less their several domestics, escaped those malignant diseases, the renowned Count Bonneval and his

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his numerous retinue continued in perfect health, to the surprise, or to use the words of Dr Kramer, to the *envy*, of all who beheld them. The only precaution he used, was to take, two or three times a-day, a small quantity of brandy in which the Peruvian bark was infused; and he obliged all his attendants and domestics to follow his example. It is no less remarkable that the count, placing his certain preservation in the use of this single medicine, lived for many years afterwards in the most unhealthy spots of Hungary, without any attack or apprehension of disease; and continued to enjoy a perfect state of health during the hottest and most sickly seasons. And thus, with an unbroken and sound constitution, which is seldom the case of those who reside long in such climates, he lived to a great age. There is an instance produced by the same author, of a whole regiment in Italy having been preserved by the use of cinchona from the attack of these malignant diseases, viz. the flux, and *bilious* fever as it is frequently called, when the rest of the Austrian army, not pursuing that method, became greatly annoyed with them.

The intemperance and irregular living of those Europeans who visit the hot climates is frequently accused as the cause of their destruction; but, our author thinks, without sufficient reason; for though intemperance will make the body more liable to receive such diseases, it will not bring them on. It must by no means, however, be imagined, that in those climates Europeans may with impunity be guilty of excesses in eating or drinking: for the least error in that way will often prove fatal by debilitating the body, whose utmost strength in time of full health was perhaps scarce sufficient to resist the pestilential miasmata of the atmosphere.

It appears, therefore, from the concurrent testimony of the most eminent physicians, that the most proper medicine to be used, either as a preventive or cure for remitting and intermitting disorders, is the Peruvian bark, administered with proper precautions and after the *primæ viæ* have been evacuated of the putrid bilious matter collected in them. In those species of *tritæophya*, &c. belonging to this class, enumerated by Sauvages, the same remedies only were useful; but in that pestilential distemper which he calls *tritæophya Vratislaviensis*, he tells us, that washing the body with water sometimes hot, sometimes cold, watery clysters, and plenty of aqueous drink, were likewise of use.

GENUS II. QUARTANA; the QUARTAN FEVER.

Quartana auctorum, *Sauv.* Gen. 89. *Lin.* 17. *Vog.* 3. *Sag.* 711. *Hoffm.* II. p. 23. *Junck.* tab. 81.

The *Genuine* QUARTAN. Sp. I. var. I. A.
Quartana legitima, *Sauv.* sp. 1. *Sydenham* de morb. acut. cap. v.

Description. The genuine quartan, according to Juncker, keeps its form more exactly than other intermittents; scarcely coming on at any other time than four or five in the afternoon. The cold is less violent than in the tertian; but is very perceptible, though it doth not proceed to such a height as to make the limbs shake; it continues for about two hours. It is preceded and accompanied by a languor both of body and mind. There is seldom any vomiting unless when the stomach is manifestly overloaded with aliment; neither is there any diarrhœa, but the belly in general is rather bound, not only on the days on which the paroxysm takes place, but also on the intermediate ones. The heat, which slowly succeeds the cold, is less troublesome to the patient by its violence than by the uneasy dryness of the skin, which is scarcely ever moistened with sweat. This heat rarely continues longer than four or five hours, unless perhaps at the first or second paroxysm. It is accompanied also with a giddiness and dull pain of the head. On the termination of the paroxysm, the patient returns to a middling state of health, and continues in the same for the rest of the intermediate days; only there remains somewhat of a loathing, and a deep-seated pain as if the person was all over bruised or broken, which kind of sensation the physicians are wont to call *osteocopus*. The fit returns every fourth day, and precisely at the same hours, being rarely postponed.

Causes of, and persons subject to, this disorder. The same general causes concur in producing this as other intermittents, namely marsh miasmata, and whatever can dispose the body to be easily affected by them. Studious people, and those of a melancholic turn, are said to be particularly subject to quartans; but what are the immediate causes which produce a return of the fits every fourth day, instead of every day, or every third day, must probably lie for ever concealed, as depending upon the secret and inexplicable mechanism of the human body.

Prognosis. A simple quartan, where there is no reason to dread any induration of the viscera, may very certainly admit of a cure; and the prognosis can never be unfavourable, unless in cases of extreme weakness, or where the distemper hath been unskilfully treated.

Cure. This does not in the least differ from that which hath been fully laid down for the simple tertian, and which it is therefore needless to repeat here.

The *Duplicated* QUARTAN. Sp. I. var. I. B.

Quartana duplicata, *Sauv.* sp. 4. *Bonet.* 153

This is entirely similar to the duplicated tertian already mentioned; proper allowance being made for the difference between the type of a tertian and quartan.

The *Triplicated* QUARTAN. Sp. I. var. I. C.

Quartana triplicata, *Sauv.* sp. 16. 154

This hath three paroxysms every fourth day, while the intermediate days are entirely free from fever.

The *Double* QUARTAN. Sp. I. var. I. D.

Quartana duplex, *Sauv.* sp. 3. *Vog.* sp. 13. 155

In the double quartan, the fits come on every day except the third; but so that the first paroxysm answers to the third, the second to the fourth, and so on.

The *Triple* QUARTAN. Sp. I. var. I. E.

Quartana triplex, *Sauv.* sp. 5. *Vog.* sp. 14. *Bartholin.* H. anat. c. I. 95. 156

This comes on every day, but the quartan type is still

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still preserved by the times of accession; that is, the time of the fourth paroxysm's coming on answers to that of the first, the fifth to the second, the sixth to the third, &c.

The QUARTAN, accompanied with *Symptoms* of other diseases. Sp. I. var. 2.

157 Quartana cataleptica, *Sauv.* sp. 7. *Bonet.* polyalth. vol. i. p. 805.
Quartana comatosa, *Sauv.* sp. 15. *Werlhof.* de febr. *C. Pisonis* Observ. de morbis à colluvie seros. obs. 166, 167, 168, 169, 171, 172, 173, 174.
Quartana epileptica, *Sauv.* sp. 8. *Scholzii* Cons. 379, 380.
Quartana hysterica, *Sauv.* sp. 10. *Morton*, Pyret. exerc. 1. cap. ix. H. 10, 11.
Quartana nephralgica, *Sauv.* sp. 9.
Quartana metastatica, *Sauv.* sp. 17.
Quartana amens, *Sauv.* sp. 12. *Sydenham* de morb. acut. cap. v.
Quartana splenetica, *Sauv.* sp. 2. *Etmuller*, Coll. consult. cas. 25.

The QUARTAN *complicated* with other *Diseases*. Sp. I. var. 3.

158 Quartana syphilitica, *Sauv.* sp. 6. *Plateri*, observ. L. III. p. 676. Edin. Ess. art. xlvii. obs. 8.
Quartana arthritica, *Sauv.* sp. 11. *Musgr. de Arthr.* sympt. cap. ix. H. 4. et 5.
Arthritis febrisequa, *Sauv.* sp. 10.
Arthritis febricosa, *Sauv.* sp. 10. *Werlhof.* de febr. *Cockburn* de morbis navigantium, obs. 19.
Quartana scorbutica, *Sauv.* sp. 14. *Barthol.* de med. Dan. diss. iv. *Tim.* L. VIII. cas. 18.

The *Remitting* QUARTAN. Sp. II.

Tetartophya, *Sauv.* gen. 85. *Sag.* 699. *Lin.* 21.
159 Quartana remittens auctorum.

Var. 1. Tetartophya simplex, *Sauv.* sp. 1.
2. Amphimerina semiquartana, *Sauv.* sp. 23.
3. Tetartophya semitertiana, *Sauv.* sp. 5.
4. Tetartophya maligna, *Sauv.* sp. 6. *Lautter.* Hist. med. cas. 21. *M. Donat.* L. III. cap. 14. ex *M. Gatenaria Horst.* L. I. obs. 15.
5. Tetartophya carotica, *Sauv.* sp. 4. *Werlhof.* de febr. *Bianchi* Hist. hep. pars III. const. ann. 1718, p. 751.
6. Tetartophya splenalgica, *Sauv.* sp. 2.
7. Tetartophya hepatalgica, *Sauv.* 3. *Cor. Pis.* in prefat. p. 33.
8. Amphimerina spasmodica, *Sauv.* sp. 16.

To the tertian or quartan fevers also belong the *Erraticæ* of authors. As all those above mentioned differ only in the slight circumstance of the type from the intermitting and remitting tertians already described at length, it is unnecessary here to take up time in describing every minute circumstance related by physicians concerning them, especially as it could contribute nothing towards the laying down a better method of cure than what hath been already suggested.

GENUS III. QUOTIDIANA; the QUOTIDIAN FEVER. Quotidia

Quotidiana auctorum, *Sauv.* gen. 86. *Lin.* 15. *Vog.* I. *Hoffm.* II. 33. *Junck.* tab. 79.

The *Genuine* QUOTIDIAN. Sp. I. var. 1. A.

Quotidiana simplex, *Sauv.* sp. 1. 16
Quotidiana legitima, *Sennert.* de febr. cap. 18.

Description. This kind of fever generally comes on about six or seven o'clock in the morning, beginning with a considerable degree of cold and shivering, which lasts for about an hour; and is often accompanied with vomiting or spontaneous diarrhœa, or both. It is succeeded by a pretty strong heat, accompanied with thirst, restlessness, and pain of the head. When the heat abates a little, a spontaneous sweat commonly follows, and the whole paroxysm rarely exceeds six hours. It returns, however, every day almost always at the same hour, unless it be evidently disturbed.

Causes of, and persons subject to, the disease. The same general causes are to be assigned for the quotidian as for other intermittents. This kind occurs but rarely; and it is said to attack people of a phlegmatic temperament rather than any other: also old people rather than young, and women rather than men.

The prognosis and method of cure are not different from those of tertians and quartans.

The *Partial* QUOTIDIAN, Sp. I. var. 1. B.

Quotidiana partialis, *Sauv.* sp. 16. *Cnoffel*, E. N. C. D. I. A. III. obs. 205. Edin. Med. Ess. vol. i. art. 31. vol. ii. art. 16. 16
Quotidiana cephalalgica, *Suav.* sp. 6. Mort. pyretol. exerc. i. hist. 27. *Van Swieten in Boerh.* p. 534.
Cephalalgia intermittens, *Sauv.* sp. 7.
Cephalæa febricosa, *Sauv.* sp. 4.
Quotidiana ophthalmica, *Morton*, ibid. hist. 17. *Van Swieten*, ibid.
Ophthalmia febricosa, *Sauv.* sp. 23.

These distempers attack only some particular part of the body, as the head, the eye, arm, &c. producing periodical affections of those parts returning once in 24 hours; they are to be cured by cinchona, as other intermittents. They are known to belong to this class, by the evident intermission of the pain or other affection of the part. The *quotidiana hysterica*, *Sauv.* sp. 3. *quotidiana catarrhalis*, *Sauv.* sp. 9. and *quotidiana stranguriosa*, *Sauv.* sp. 11. seem to be symptomatic disorders.

The *Remitting* QUOTIDIAN. Sp. II.

Amphimerina, *Sauv.* gen. 84. *Lin.* 20. 16
Quotidiana continua, *Vog.* 15.
Quotidianæ remittentes et continuæ auctorum.
Amphimerina latica, *Sauv.* sp. 1.
Febris continua lymphatica, *Etmuller*, Coll. conf. cas. 32. *River.* Obs. cent. 1. obs. 57.
Amphimerina singultuosa, *Sauv.* sp. 14.
Febris continua Lyngodes, *Vog.* 26.

Concerning these also nothing remains necessary to be mentioned in this place, having already so fully discussed the remitting fevers in all the differents parts of the

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the world. Many other varieties of these fevers mentioned by different authors are to be accounted merely symptomatic.

Sect. II. CONTINUED FEVERS.

Continuæ, *Sauv.* class ii. ord. 1. *Vog.* class i. ord. 2. *Sag.* 666. *Boerh.* 727.
Continentes, *Lin.* class ii. ord. 1. *Stahl.* Cas. mag. 35. Cas. min. 87. *Junck.* 58. *Sennert.* de febr. L. ii. cap. 2. et 10.

Genus IV. SYNOCHA.

Synocha, *Sauv.* gen. 80. *Lin.* 12. *Junck.* 58.
Synocha, sive febris acuta sanguinea, *Hoffm.* II. 105.
Synochus, *Vog.* 16.
Continua non putris, *Boerh.* 720.
Ephemera, *Sauv.* g. 79. *Boerh.* 728. *Junck.* 57.
Diaria, *Lin.* 11.
Febris inflammatoria auctorum.

Description. The most simple kind of synocha is the ephemera or diary fever. It begins without any sensation of cold or shivering, unless there be some internal inflammation, or the smallpox or measles happen to be present. A continual heat without any intermission constitutes the essence of this disease. The heat, however, is more tolerable than in the synocha properly so called. In some, the pains of the head are pungent and throbbing, answering to the pulsations of the arteries; but in others they are dull and heavy. The face is red and bloated; and there is a remarkable lassitude of the limbs, with a strong, full, and frequent pulse. The urine is red, and deposits a sediment almost of the colour of orange-peel; and in the very first day of the disease, signs of concoction (according to the Hippocratic phrase) appear. The fever commonly goes off with a gentle sweat; but sometimes, though more rarely, with a hemorrhagy by the nose. Its shortest period is 24 hours: but if it goes beyond the fourth day, it is then a *synocha* properly so called.

The simple synocha, according to Vogel, begins with cold and shivering, succeeded by vehement heat, redness, and dryness of the skin. The face, especially, is very red, and the thirst intense. The head is either pained or heavy. The patient either doth not sleep at all, or is disturbed with dreams. A moist sweat then breaks out all over the skin. The pulse is full, quick, and frequent; the judgment is sometimes a little disturbed; young people are apt to be terrified with imaginations; and they for the most part incline to sleep; the respiration is difficult, and the belly costive; at the same time that a tensive kind of lassitude is perceived over the whole body. A complete crisis takes place either on the fourth or at the farthest on the eleventh day. The characteristic marks of the simple synocha, therefore, are, A redness of the face, moisture of the skin, a strong and frequent pulse.

Causes of, and persons subject to, this disease. As we have already remarked of intermittents, so must we also now remark of continued fevers, that it is impossible to discover those minute causes which occasion the difference of type betwixt one inflammatory fever and another, though most authors pretend to enumerate these with great certainty. Thus Juncker tells us, that the cause of the simple ephemera is plethora, together with any immoderate agitation and commotion of the fluids while in that state. Vogel reckons among the causes of his *febris diaria*, passions of the mind, pain, want, exposure to the sun, &c.; a repulsion or absorption of certain humours; wounds, fractures, luxations, &c.; so that in general we may reckon every thing tending to increase the action of the arterial system to be in certain circumstances a cause of inflammatory fever.—Hence we find those are most subject to the synocha whose constitution is either naturally robust, or who are exposed to those causes which tend to produce an increased action of the arterial system; such as hard labour, high living, &c.

Prognosis. The most simple kind of synocha, that is, the ephemera or diary fever, is commonly cured without the assistance of medicine, and therefore the prognosis is for the most part favourable: yet, if it be improperly treated by heating medicines, it may easily be converted into the other kind; or, if there be a putrid disposition of the fluids, into a fever of a very dangerous nature. The same thing is to be understood even of the most violent kind; for simple inflammatory fevers are not dangerous unless complicated with an affection of some particular part, as the pleura, stomach, &c.

Cure. Dr Cullen objects to the plan of those who are for leaving the cure of continued fevers to the operations of nature; because these operations are neither certain in themselves, nor are they so well understood as to enable us to regulate them properly; and it is likewise possible to supersede them by art. The plan therefore on which he proceeds is, to form his indications of cure upon the means of obviating the tendency to death in fevers; and these he reduces to three. 1. To moderate the violence of reaction.—2. To remove or obviate the causes of debility; and, 3. To obviate or correct the tendency of the fluids to putrefaction.

The *first* indication may be answered, 1. By all those means which diminish the action of the heart and arteries. 2. By those which take off the spasm of the extreme vessels, which, according to his theory, is the chief cause of violent reaction.

I. The action of the heart and arteries may be diminished, 1. By avoiding or moderating those irritations which, in one degree or other, are almost constantly applied to the body. 2. By the use of certain sedative powers. 3. By diminishing the tension or tone of the arterial system.

[1.] The irritations above mentioned are the impressions made upon our senses, the exercise of the body and mind, and the taking in of aliments. The avoiding of these as much as possible, or the moderating their force, makes what is properly called the *antiphlogistic regimen*, proper to be employed in *almost* every continued fever. This regimen is to be directed in the following manner.

1. Impressions on the external senses, as stimulant to the system, and a chief support of its activity, should be avoided as much as possible; especially such as are of a stronger kind, and which give pain and uneasiness. No impression is to be more carefully guarded against than that of external heat; and at the same

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2. All motion of the body is to be avoided as much as possible, and that posture only chosen which employs the fewest muscles, and keeps none of them long in a state of contraction. Speaking, as it accelerates respiration, is particularly to be avoided. It must also be observed, that every motion of the body is more stimulant in proportion as the patient is weaker.

3. The exercise of the mind is also to be avoided, as being a stimulus to the body; but here an exception is to be made in the case of a delirium coming on, when the presenting of accustomed objects may divert the irregular train of ideas then arising in the mind.

4. The presence of recent aliment in the stomach proves always a stimulus to the system, and ought therefore to be as moderate as possible. A total abstinence for some time may be of service; but as this cannot be long continued with safety, we must avoid the stimulus of aliment by choosing that kind which gives the least. Alimentary matters are also to be accounted more stimulant in proportion to their alkalescent qualities; and this leads us to avoid all animal, and use only vegetable food. For the same reason, aromatic and spirituous liquors are to be avoided; and in answering the present indication, we must abstain from all fermented liquors except those of the lowest quality. Other stimuli are, the sensation of thirst, crudities or corrupted humours in the stomach, a preternatural retention of the fæces in the intestines, and a general acrimony of all the humours, which is in most fevers to be suspected. These are to be removed by such methods as the urgency of the symptoms require, by diluting liquors, vomiting, the use of acids, laxative elysters, and large quantities of antiseptic drinks.

[2.] The second method of moderating the violence of reaction is by the employment of certain sedative powers, with a view to diminish the activity of the whole body, and particularly that of the sanguiferous system. The first of these to be mentioned is the application of cold. Heat is the chief support of the activity of the animal-system; and the system is therefore provided with a power of generating heat: but at the same time we may observe, that this would go to excess, were it not constantly moderated by a cooler temperature in the surrounding atmosphere. When, therefore, the generating power of heat in the system is increased, as is commonly the case in fevers, it is necessary not only to avoid all further means of increasing it, but also to apply air of a cooler temperature; or at least to apply it more entirely and freely than in a state of health. This is shown, from some late observations, to be a very powerful means of moderating the violence of re-action: but what is the mode of its operation, to what circumstances of fever it particularly applies, or what limitations it requires, are not yet fully ascertained.

Synocha. Another sedative power very frequently employed in fevers, is that of certain medicines known in the materia medica by the name of *refrigerants*. The chief of these are acids of all kinds when sufficiently diluted, and which are, in several respects, remedies adapted to continued fevers. Those especially in use are the sulphuric and vegetable; and on many accounts the latter are to be preferred. Another set of refrigerants are the neutral salts formed of the sulphuric, nitrous or vegetable acids, with alkalies either fixed or volatile. All these neutrals, while they are dissolved in water, generate cold; but as that cold ceases soon after the dissolution is finished, and as the salts are generally exhibited in a dissolved state, their refrigerant power in the animal body does not all depend upon their power of generating cold with water. Nitre is the refrigerant chiefly employed; but all the others, compounded as above mentioned, partake more or less of the same quality. Besides these neutrals, some metallic salts have also been employed in fevers, particularly the acetite of lead: but the refrigerant powers of this salt are by no means ascertained, and its deleterious qualities are too well known to admit of its being freely used.

[3.] The third general method of diminishing the reaction, is by lessening the tension, tone, and activity of the sanguiferous system. As the activity of the system in a great measure depends upon the tone, and this again upon the tension, of the vessels, given to them by the quantity of fluids they contain, it is evident, that the diminution of the quantity of these must diminish the activity of the sanguiferous system. The most efficacious means of diminishing the quantity of fluids is by the evacuations of blood-letting and purging. The former is evidently one of the most powerful means of diminishing the activity of the whole body, and especially of the sanguiferous system; and it must therefore be the most effectual means of moderating the reaction in fevers. When the violence of reaction, and its constant attendant a phlogistic diathesis, are sufficiently evident; when these constitute the principal part of the disease, and may be expected to continue through the whole of it, as in the cases of synocha; then blood-letting is the principal remedy, and may be employed as far as the symptoms of the disease may seem to require, and the constitution of the patient will bear. It must, however, be remarked, that a greater evacuation than is necessary may occasion a slower recovery, and render the person more liable to a relapse, or bring on other diseases. It is also to be observed, that this evacuation is the more effectual, as the blood is more suddenly drawn off, and as the body is at the same time more free from all irritation, and therefore when it is in a posture in which the fewest muscles are in action.

With regard to purging, when we consider the quantity of fluids constantly present in the cavity of the intestines, and the quantity which may be drawn off from the innumerable excretories that open into this cavity, it will be obvious, that a very great evacuation may be made in this way; and if this be done by a stimulus that is not at the same time communicated to the rest of the body, it may, by emptying both the cavity of the intestines and the arteries which furnish

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furnish the excretions poured into it, induce a considerable relaxation in the whole system; and is therefore suited to moderate the violence of reaction in fevers. But it is to be observed, that as the fluid drawn from the excretories opening into the intestines is not all drawn immediately from the arteries, and as what is even more immediately drawn from these is drawn off slowly; so the evacuation will not, in proportion to its quantity, occasion such a sudden depletion of the red vessels as blood-letting does; and therefore cannot act so powerfully in taking off the phlogistic diathesis of the system.

At the same time this evacuation may induce a considerable degree of debility; and therefore, in those cases in which a dangerous state of debility is likely to occur, purging is to be employed with a great deal of caution; and this caution is more difficult to be observed than in the case of blood-letting: and it is further to be noticed, that as purging takes off in some measure the determination of the blood to the vessels on the surface of the body, it seems to be less adapted to the cure of fevers.

II. The other method of moderating the violence of reaction in fevers is by the exhibition of those remedies suited to take off the spasm of the extreme vessels, supposed to be the irritation which chiefly supports the reaction. The means to be employed for this purpose are either internal or external.

First, The internal means are, 1. Those which determine the force of the circulation to the extreme vessels on the surface of the body, and by restoring the tone and activity of those vessels, overcome the spasm on their extremities. 2. Those medicines which have the power of taking off spasm in any part of the system, and which are known under the title of ANTISPASMODICS.

(1.) Those remedies which are fit to determine to the surface of the body are, 1. Diluents. 2. Neutral salts. 3. Sudorifics. 4. Emetics.

1. Water enters, in a large proportion, into the composition of all animal fluids, and a large quantity of it is always diffused through the whole of the common mass. In a sound state, the fluidity of the whole mass depends upon the quantity of water present in it. Water therefore is the proper diluent of our mass of blood, and other fluids are diluent only in proportion to the quantity of water they contain.

In a healthy state, also the fulness of the extreme vessels and the quantity of excretion are in proportion to the quantity of water present in the body. But in fever, though the excretions be in some measure interrupted, they continue in such quantity as to exhale the more fluid parts of the blood; and, while a portion of them is at the same time necessarily retained in the larger vessels, the smaller, and the extreme vessels, both from the deficiency of fluid and their own contracted state, are less filled, and therefore allowed to remain in that condition. To remedy this contracted state, nothing is more necessary than a large supply of water or watery fluids taken in by drinking or otherwise; for as any superfluous quantity of water is forced off by the several excretories, such a force applied may be a means of dilating the extreme vessels, and of overcoming the spasm affecting their extremities. Accordingly, the throwing in a large quantity of watery fluids, has been, at all times, a remedy much employed in fevers; and in no instance more remarkably than by the Spanish and Italian physicians, in the use of what they call the *diæta aquea*. This practice consists in taking away every other kind of aliment and drink, and in giving, in divided portions, every day for several days together, six or eight pounds of plain water, generally cold, but sometimes warm. This, however, is to be done only after the disease has continued for some time, and at least for a week.

2. A second mean of determining to the surface of the body, is by the use of neutral salts. These neutrals, in a certain dose, taken into the stomach, produce soon after a sense of heat upon the surface of the body; and, if the body be covered close and kept warm, a sweat is readily brought out. The same medicines taken during the cold stage of a fever, very often put an end to it, and bring on the hot one; and they are also remarkable for stopping the vomiting which so frequently attends the cold stage of fevers. All this shows, that neutral salts have a power of determining the blood to the surface of the body, and may therefore be of use in taking off the spasm which subsists there in fevers. The neutral most commonly employed in fevers, is that formed of an alkali with the native acid of vegetables. But all the other neutrals have more or less of the same virtue; and perhaps some of them, particularly the ammoniacal salts, possess it in a stronger degree. As cold water taken into the stomach often shows the same diaphoretic effects with the neutral salts, it is probable that the effect of the latter depends upon their refrigerant powers.

3. A third method of determining to the surface of the body, and taking off the spasm subsisting there, is by the use of sudorifics and by sweating. The propriety of this practice has been much disputed; and many specious arguments may be adduced both for and against it. In its favour may be urged, 1. That in healthy persons, in every case of increased action of the heart and arteries, a sweating takes place, and is, seemingly, the means of preventing the bad effects of such increased action. 2. That, in fevers, their most usual solution and termination is by spontaneous sweating. 3. That, even when excited by art, it has been found useful at certain periods and in certain species of fever.—On the other hand, it may be urged against the practice of sweating, 1. That in fevers, as a spontaneous sweating does not immediately come on, there are some circumstances different from those in a state of health, and which may render it doubtful whether the sweating can be safely excited by art. 2. That in many cases the practice has been attended with bad consequences. The means commonly employed have a tendency to produce an inflammatory diathesis; which, if not taken off by the sweat succeeding, must be increased with much danger. Thus sweating employed to prevent the accessions of intermitting fevers has often changed them into a continued form, which is always dangerous. 3. The utility of the practice is doubtful; as sweating, when it happens, does not always give a final termination, as must be manifest in the case of intermittents, and in many continued fevers which are sometimes in the beginning attended with sweatings which do not prove final; and, on the contrary, whether they be spontaneous

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neous or excited by art, they seem often to aggravate the disease.

From these considerations, it is doubtful if the practice of sweating can be admitted very generally; but, at the same time, it is also very doubtful if the failure of the practice, or the mischiefs said to arise from it, hath not been owing to the improper conduct of the practitioner. With respect to the last, it is almost agreed among physicians, 1. That sweating has been generally hurtful when excited by stimulant, heating, and inflammatory medicines. 2. That it has been hurtful when excited by much external heat, and continued with a great increase of the heat of the body. 3. That it is always hurtful when it does not relieve; and rather increases the frequency and hardness of the pulse, the anxiety and difficulty of breathing, the headach, and delirium. 4. That it is always hurtful if it be urged when the sweat is not fluid, and when it is partial and on the superior parts of the body only.

In these cases, it is probable, that either an inflammatory diathesis is produced, which increases the spasm on the extreme vessels; or that, from other causes, the spasm is too much fixed to yield easily to the increased action of the heart and arteries: and upon either supposition it must be obvious, that urging the sweat may produce determinations to some of the internal parts, with very great danger.

Notwithstanding these doubts, however, it still remains true, 1. That sweating has been often useful in preventing the accessions of fevers when they have been certainly foreseen, and a proper conduct employed. 2. That even after fevers have in some measure come on, sweating has interrupted their progress when properly employed, either at the very beginning of the disease, or during its approach and gradual formation. 3. That even after pyrexiæ have continued for some time, sweating has been successfully employed in curing them, as is particularly exemplified in the case of a rheumatism. 4. That certain fevers produced by a very powerful sedative contagion, have been generally treated most successfully by sweating.

These instances are in favour of sweating, but give no general rule; and it must be left to farther experience to determine how far any general rule can be established in this matter. In the mean time, if the practice of sweating is to be attempted, the following rules may be laid down for the conduct of it: 1. That a sweat should be excited without the use of stimulant inflammatory medicines. 2. That it should be excited with as little external heat, and with as little increase of the heat of the body, as possible. 3. That, when excited, it should be continued for a due length of time; not less than 12 hours, and sometimes for 24 or 48 hours; always, however, supposing that it proceeds without the dangerous circumstances already mentioned. 4. That for some part of the time, and as long as the person can easily bear, it should be carried on without admitting of sleep. 5. That it should be rendered universal over the whole body; and therefore particularly that care should be taken to bring the sweating to the lower extremities. 6. That the practice should be rendered safer by moderate purging excited at the same time. 7. That it should not be suddenly checked by cold anyhow applied to the body.

When attention is to be given to these rules, the sweating may be excited, 1. By warm bathing, or a fomentation of the lower extremities. 2. By frequent draughts of tepid liquors, chiefly water, rendered more grateful by the addition of a light aromatic, or more powerful by that of a small quantity of wine. 3. By giving some doses of neutral salts. 4. Most effectually, and perhaps most safely, by a large dose of an opiate, joined with a portion of neutral salts, and of an emetic.

The fourth mean of determining to the surface of the body, and thereby taking off the spasm affecting the extreme vessels, is by the use of emetics. These, particularly of the antimonial kind, have been employed in the cure of fevers ever since the introduction of chemical medicines; but though of late their use has become very general, their efficacy is still disputed, and their manner of operating is differently explained.

Vomiting is in many respects useful in fevers: as it evacuates the contents of the stomach, as it emulges the biliary and pancreatic ducts, and evacuates the contents of the duodenum, and perhaps also of a large portion of the intestines; as it agitates the whole of the abdominal viscera, it expedes the circulation in them, and promotes their several secretions; and, lastly, as it agitates also the viscera of the thorax, it has like effects there.

It is not to this cause, however, that we are to impute the effect vomiting has in determining to the surface of the body. This must be attributed to the particular operation of emetics upon the muscular fibres of the stomach, whereby they excite the action of the extreme arteries on the surface of the body, and by this means effectually determine the blood to these vessels, remove the atony, and take off the spasm affecting them. For this purpose they are exhibited in two different ways; that is, either in such doses as may excite full and repeated vomitings, or in such doses as may excite sickness and nausea only, with little or no vomiting at all.

Full vomiting is well suited to determine to the surface of the body, and thereby to obviate the atony and spasm which lay the foundation of fever. Thus, vomiting, excited a little before the expected accession of the paroxysm of an intermittent, has been found to prevent the paroxysm altogether. It has been observed also, that when contagion has been applied to a person, and first discovers its operation, an emetic given has prevented the fever which might otherwise have been expected.

These are the advantages to be obtained by exciting vomiting at the first approach of fevers, or of the paroxysm of fevers; and they may also be applied after fevers are formed, to take off, perhaps entirely, the atony and spasm, or at least to moderate these, so that the fever may proceed more gently and safely. It is seldom, however, that vomiting is found to produce a final solution of fevers; and after they are once formed, it it commonly necessary to repeat the vomiting several times; but this is attended with inconveniency, and sometimes with disadvantage. The operation of full

full vomiting is transitory, and the exercise of vomiting is a debilitating power; and therefore, when the vomiting does not remove the atony and spasm very entirely, it may give occasion to their recurrence with greater force. For these reasons, after fevers are fully formed, some physicians have thought proper to employ emetics in nauseating doses only. These are capable of exciting the action of the extreme vessels, and their operation is more permanent. At the same time they often show their power by exciting some degree of sweat, and their operation is rendered more safe by their commonly producing some evacuation by stool. But nausea continued for any great length of time, is to most patients a sensation highly distressing, and almost insufferable.

The emetics chiefly in use at present are, ipecacuanha and antimony. The former may be employed for determining to the surface of the body: but, even in very small doses, it so readily excites vomiting, that it is with difficulty employed for the purpose of nauseating only; and in whatever manner employed, there is reason to suspect that its effects are less permanent, and less powerfully communicated from the stomach to the rest of the system, than those of antimony. This last is therefore generally preferred; and its preparations, seemingly various, may all be reduced to two heads; one comprehending those in which the reguline part is in a condition to be acted upon by acids, and therefore on meeting with acids in the stomach it becomes active; and another, comprehending those preparations in which the reguline part is already joined with an acid, rendering it active. Of each kind there are great numbers, but not differing essentially from one another; the two most worthy of notice are, the *calx nitrata antimonii*, and *emetic tartar*, or *tartrite of antimony*, of the Edinburgh Dispensatory. Both these are very efficacious medicines; but the latter seems preferable, because its dose is capable of being better ascertained; though the former, on account of its slower operation, may have some advantages, and in certain cases be more efficacious as a purgative and sudorific.

The *calx nitrata antimonii*, when first introduced into the pharmacopœia of the Edinburgh college was supposed to be very nearly, if not precisely, the same with a medicine which has of late been highly celebrated in the cure of fevers, Dr James's powder. But from more accurate observations, there is now reason to believe that the pulvis antimonialis of the London Pharmacopœia, formed by the calcination of antimony with hartshorn, approaches more nearly to that celebrated arcanum. But at any rate, the calx antimonii nitrata, the pulvis antimonialis, and James's powder, are probably not essentially different from each other. The two latter, however, have the most near resemblance; and accordingly the Edinburgh college, in their Pharmacopœia, have introduced an article under the title of *antimonium calcarco-phosphoratum*, which they consider as so much similar to James's powder, that they have used as a synonyme for it, the title of *pulvis Jacobi*.

The time most proper for exhibiting those medicines is a little before the accession, when that can be certainly known. In continued fevers the exacerbations are not always very observable; but there is reason to believe, that one commonly happens about noon or soon after it; and that these, therefore, are the most proper times for exhibiting emetics.

With respect to the manner of administration, that of the *calx nitrata* is simple, as the whole of what is thought a proper dose may be given at once; and no more can be properly given till the next accession. The administration of the emetic tartar is different. It is to be given in small doses, not sufficient to excite vomiting; and these doses are to be repeated after short intervals for several times, till sickness, nausea, and some, though not much, vomiting come on. The difference of administration must depend upon the dose, and the length of the interval at which it is given. If it be intended that the medicine should certainly operate by stool, the doses are made small, and the intervals long. On the contrary, when vomiting is proper, or when much purging ought to be avoided, and therefore some vomiting must be admitted, the doses are made larger, and the intervals shorter. With respect to both kinds of preparations, the repetition is to be made at the times of accession, but not very often: for if the first exhibitions, duly managed, have little effect, it is seldom that the after exhibitions have much; and it sometimes happens that the repeated vomiting, and especially repeated purging, does harm by weakening the patient.

(2.) The other set of internal medicines which are supposed useful in taking off the spasm of the extreme vessels, are those named *antispasmodics*. But whatever may be the virtues of some of them in this way, such is their power of stimulating at the same time, that very few of them can with safety be administered in fevers of an inflammatory nature. Almost the only one which can with safety be exhibited in these cases is camphor; and the operations of this are by no means well ascertained. Dr Huxham mentions it as a corrector of the acrimony of cantharides; and assures us, that it very effectually promotes a diaphoresis. But from the remarks of other practitioners, we have no just reason to suppose that it acts perceptibly in a dose of five or six grains, though in 15 or 20 it produces a particular kind of intoxication.

Secondly, The external means suited to take off the spasm of the extreme vessels, are blistering and warm bathing.

1. What are the effects of blistering so frequently employed in fevers is not yet agreed among physicians. Dr Cullen is of opinion, that the small quantity of cantharides absorbed from a blistering plaster, is not sufficient to change the consistence of the mass of blood; and therefore, that such a quantity can neither do good by resolving phlogistic lentor if it exists, nor do harm by increasing the dissolution of the blood arising from a putrid tendency in it. The effects of cantharides upon the fluids, therefore, may be entirely neglected. The inflammation produced by the application of cantharides to the skin, affords a certain proof of their stimulant power: but in many persons the effect of that stimulus is not considerable; in many it is not communicated to the whole system; and even when it does take place in the whole system, it seems to be taken off very entirely by the effusion and evacuation of serum from the blistered part. It may be concluded, therefore, that neither much good is to be expected,

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nor much harm to be apprehended, from the stimulant power of blistering; and the certainty of this conclusion is established by the great benefit arising from the proper practice of blistering in inflammatory diseases. Much has been imputed to the evacuation made by blistering; but it is never so considerable as to affect the whole system; and therefore can neither, by a sudden depletion, relax the sanguiferous system, nor by any revulsion affect the general distribution of the fluids. The evacuation, however, is so considerable as to affect the neighbouring vessels; and the manifest utility of blistering near the part affected in inflammatory diseases leads us to think, that blistering, by deriving to the skin, and producing an effusion there, relaxes the spasm of the deeper seated vessels. It is in this manner, most probably, that the tumor of a joint, from an effusion into the cellular texture under the skin, takes off the rheumatic pain formerly affecting that joint. Analogous to this, probably, is the good effect of blistering in continued fevers, arising from the relaxation of the spasm of the extreme vessels by a communication of the blistered part with the rest of the skin. A blister may be employed at any period in continued fevers; but it will be of most advantage in the advanced state of such fevers, when, the reaction being weaker, all ambiguity from the stimulating power of blistering is removed, and when it may best concur with other circumstances tending to a final solution of the spasm.

From this view of the matter, it will appear that the part of the body to which blisters ought to be applied is indifferent, except upon the suspicion of topical affection, when the blistering is to be made as near as possible to the part affected. Whether sinapisms and other *rubefacientia* act in a manner analogous to what has been supposed of blistering may be doubtful; but their effects in rheumatism and other inflammatory diseases render it probable.

2. The other external means of taking off the spasm of the extreme vessels is warm bathing. This was frequently, and in different circumstances, employed by the ancients; but has, till very lately, been neglected by modern physicians. As the heat of the bath stimulates the extreme vessels, and, with the concurrence of moisture, also relaxes them, it seems to be a safe stimulus, and well suited to take off the spasm affecting these vessels. It may be applied to the whole body by immersion; but this is in many respects inconvenient. From extensive experience it appears, that most of the purposes of warm bathing can be obtained by a fomentation of the legs and feet, it properly administered, and continued for a due length of time, not less than an hour. The marks of the good effects of such a fomentation are, the patient's bearing it easily, its relieving delirium, and inducing sleep.

164 GENUS V. TYPHUS; *the Typhous Fever.*

Typhus, *Sauv.* gen. 82. *Sag.* 677.

165 I. Typhus mitior, or the *Slow Nervous Fever.* Sp. 1. var. 1.

Febris maligna hectica convulsiva, sive lues νευρωδης *Willis* de morb. convulsiv. cap. 8.

Febris pestilens, *Fracastor.* de morb. contag. lib. ii. cap. 4.

Febris pestilens, sine charactere veneni, *Forest*, l. vi. obs. 26.

Febris hectica pestilens, *Forest*, l. vi. obs. 32.

Febris nova ann. 1685, *Sydenham*, Sched. monitor.

Febris putrida nervosa, *Wintringh.* Com. Nosolog. ad ann. 1720, 1721.

Febris lenta nervosa, *Huxham* on fevers, chap. 8.

Febris contagiosa, *Lind* on fevers and infection, *passim.*

Typhus nervosus, *Sauv.* sp. 2.

Typhus comatosus, *Sauv.* sp. 3.

Tritæophya typhodes Mangeti, *Sauv.* sp. 11. *Raym. Fort.* de febribus.

Typhi

Description. Of all the descriptions we have of the nervous fever, that of Dr Huxham is perhaps the best. According to him, the patient at first grows somewhat listless, and feels slight chills and shudders, with uncertain flushes of heat, and a kind of weariness all over, like what is felt after great fatigue. This is always attended with a sort of heaviness and dejection of spirit, and more or less of a load, pain, or giddiness of the head; a nausea or disrelish of every thing soon follows, without any considerable thirst, but frequently with retching to vomit, though little but insipid phlegm is brought up. Though a kind of lucid interval of several hours sometimes intervenes, yet the symptoms return with aggravation, especially towards night; the head grows more giddy or heavy; the heat greater; the pulse quicker, but weak; with an oppressive kind of breathing. A great torpor, or obtuse pain and coldness, affects the hinder part of the head frequently, and oftentimes a heavy pain is felt on the top all along the *coronary suture*; this, and that of the back part of the head, generally attend nervous fevers, and are commonly succeeded by some degree of a delirium. In this condition the patient often continues for five or six days, with a heavy, pale, sunk countenance; seemingly not very sick, and yet far from being well; restless, anxious, and commonly quite void of sleep, though sometimes very drowsy and heavy; but although he appears to those about him actually to sleep, he is utterly insensible of it. The pulse during all this time is quick, weak, and unequal; sometimes fluttering, and sometimes for a few moments slow; nay, even intermitting, and then with a sudden flush in the face, immediately very quick, and perhaps soon after surprisingly calm and equal; and thus alternately. The heats and chills are as uncertain and unequal; sometimes a sudden colour and glow arise in the cheeks, while the tip of the nose and ears is cold, and the forehead at the same time in a cold dewy sweat. Nay, it is very common, that a high colour and heat appear in the face, when the extremities are quite cold. The urine is commonly pale, and often limpid; frequently of a whey colour, or like vapid small beer, in which there is either no manner of sediment, or a kind of loose matter like bran irregularly scattered up and down in it. The tongue at the beginning is seldom or never dry or discoloured, but sometimes covered with a thin whitish mucus: at length, indeed, it often appears very dry, red, and chapped, or of the colour of pomegranate rind; but this chiefly at the close of the disease: yet, however dry the tongue and lips seem, the patient seldom complains of thirst, though sometimes of a heat in the tongue. About the seventh or eighth day, the giddiness

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giddiness, pain, or heaviness of the head become much greater, with a constant noise in it, or *tinnitus aurium;* which is very disturbing to the sick, and frequently brings on a delirium. The load on the præcordia, anxiety and faintness, grow much more urgent; and patients often fall into an actual deliquium, especially if they attempt to sit up; cold sweats suddenly come out on the forehead, and on the backs of the hands (though at the same time there be too much heat in the cheeks and palms), and as suddenly go off. If the urine now grow more pale and limpid, a delirium is certainly to be expected, with universal tremors and *subsultus tendinum;* the delirium is seldom violent, but as it were a confusion of thought and action, muttering continually and faltering in their speech. Sometimes they awake only in a hurry and confusion, and presently recollect themselves, but forthwith fall into a muttering dozy state again. The tongue grows often very dry at the height, especially in its middle part, with a yellowish list on each side, and trembles greatly when the sick attempts to put it out. Frequently profuse sweats pour forth all at once, about the ninth, tenth, or eleventh day, commonly coldish and clammy on the extremities; oftentimes very thin stools are discharged, and then nature sinks apace; the extremities grow cold, the nails pale or livid; the pulse may be said to tremble and flutter, rather than to beat, the vibrations being so exceedingly weak and quick that they can scarce be distinguished; though sometimes they creep on surprisingly slow, and very frequently intermit. The sick become quite insensible and stupid, scarce affected with the loudest noise or the strongest light; though, at the beginning, strangely susceptible of the impressions of either. The delirium now ends in a profound coma, and that soon in death. The stools, urine, and tears, run off involuntarily, and denounce a speedy dissolution, as the tremblings and twitchings of the nerves and tendons are preludes to a general convulsion, which at once snaps the thread of life. In one or other of these ways are the sick carried off, after having languished for 14, 18, or 20 days; nay, sometimes much longer. Most patients grow deaf and stupid towards the end of this disease (some extremely deaf), though too quick and apprehensive at the beginning; insomuch that the least noise or light greatly offended them. Many from their immoderate fears seem to hurry themselves out of life, where little danger is apparent at the beginning: nay, some will not allow themselves to sleep, from a vain fear of dozing quite away; and others from the vast hurry, anxiety, and confusion of which they are sensible either during sleep or at their waking.

Causes of, and persons subject to, this disorder. The nervous fever is most frequently the consequence of contagion. It most commonly attacks persons of weak nerves, a lax habit of body, and a poor thin blood; those who have suffered great evacuations, a long dejection of spirits, immoderate watchings, studies, fatigue, &c.; also those who have used much crude unwholesome food, vapid impure drinks, or who have been confined long in damp foul air; who have broken the vigour of their constitutions by salivations, too frequent purging, immoderate venery, &c. Hence we see how the disease is connected with an extreme debility of the nervous system; for when people are prepared for this fever by having their nerves already weakened, the contagious particles immediately attack the nervous system, without so much affecting the state of the blood or juices, though the latter are greatly affected in the putrid malignant fevers.

Prognosis. In nervous fevers, the prognosis is very much the same with that of the putrid malignant kind. And although death be not so frequent as in that modification of fever, yet it may justly be considered as a very fatal disease.

Cure. As this fever is produced by contagion affecting the nervous system of a person already debilitated, and thus producing weakness in an extreme degree, we have now occasion to consider Dr Cullen's *two indications* of cure omitted under the *Synocha;* namely, to remove the cause and obviate the effects of debility, and to correct the putrescent tendency of the fluids; for though, in the beginning of nervous fevers, the tendency to putrefaction be not remarkable, it becomes exceedingly great towards their conclusion.

[1.] In answering the first indication, Dr Cullen observes, that most of the sedative powers inducing debility cease to act soon after they have been first applied; and therefore the removing them is not an object of the present indication. There is only one which may be supposed to continue to act for a long time, and that is the contagion applied; but we know nothing in the nature of contagion that can lead us to any measures for removing or correcting it. We know only its effects as a sedative power inducing debility, or as a ferment inducing a tendency to putrefaction in the fluids, the former of which at present falls under our consideration.—The debility induced in fevers by contagion, or other causes, appears especially in the weaker energy of the brain; but in what this consists, or how it may be restored, we do not well know; but as nature, seemingly for this purpose, excites the motion of the heart and arteries, we must ascribe the continuance of the debility to the weaker re-action of the sanguiferous system: the means, therefore, which we employ for obviating debility, are immediately directed to support and increase the action of the heart and arteries; and the remedies employed are tonics or stimulants.

In contagious diseases we know, both from the effects which appear, and from dissections, that the tone of the heart and arteries is considerably diminished; and that tonic remedies are therefore properly indicated. We are to consider these remedies as of two kinds; 1. The power of cold; 2. That of tonic medicines.

The power of cold as a tonic in fevers may be employed in two ways: either as thrown into the stomach, or as applied to the surface of the body. As we have already observed that the power of cold may be communicated from any one part to every other part of the system, so it will be readily allowed that the stomach is a part as fit as any other for this communication, and that cold drink taken into the stomach may prove an useful tonic in fevers. This the experience of all ages has confirmed, but at the same time it has been frequently observed, that, in certain circumstances, cold drink taken into the stomach has proved very hurtful; and therefore that its use in fevers requires some limitations,

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tations. What these limitations should be, and what are all the circumstances which may forbid the use of cold drink, it is difficult to determine; but it seems, clearly forbidden in all cases where a phlogistic diathesis prevails in the system, and more especially when there are topical affections of an inflammatory nature.

The other method of employing cold as a tonic, is by applying it to the surface of the body, as a refrigerant power fit to moderate the violence of reaction; but probably it may here also be considered properly as a tonic, and useful in cases of debility.—Not only cool air, but cold water also may be applied to the surface of the body as a tonic. The ancients frequently applied it with advantage to particular parts as a tonic; but it is a discovery of modern times, that, in the case of putrid fevers attended with much debility, the body may be washed all over with cold water. This was first practised at Breslaw in Silesia, as appears from a dissertation under the title of *Epidemia Verna, quæ Wratislaviam, anno* 1737 *afflixit*, to be found in the *Acta Nat. Curios.* vol. x. And from other writers it appears, that the practice has passed into some of the neighbouring countries. But in Britain the use of cold water externally applied has of late been more extensively introduced than into any other country of Europe. For this we are chiefly indebted to the late ingenious Dr Currie of Liverpool. He has recommended the dashing cold water over the whole surface of the body, as a means not only of obviating heat, delirium, and other symptoms most urgent; but of putting an immediate stop to the disease. And there can be no doubt that the practice has often been attended with the most salutary consequences. But it is by no means so generally advantageous as Dr Currie and some others are inclined to believe. It is in but very rare instances that an artificial termination of fever can thus be obtained; and even as obviating symptoms, it is not unfrequently attended with bad consequences. It can never be employed with safety unless where the heat is very urgent. And perhaps all the advantages of cold immersion may be obtained merely from cold washing, a practice now very common in Britain.

The medicines which have been employed in fevers as tonics are various. If the acetite of lead hath been found useful, it is probably as a tonic rather than as a refrigerant; and the *ens veneris*, or rather preparations of iron which have been employed, can act as tonics only. The preparations of copper, from their effects in epilepsy, are presumed to possess a tonic power; but whether their use in fevers be founded on their tonic or emetic powers, is uncertain. And upon the whole there may no doubt occur some instances of fevers being cured by tonics taken from the fossil kingdom; but the vegetable tonics are the most efficacious, and among these the cinchona certainly holds the first place.

The cinchona has commonly been considered as a specific, or a remedy of which the operation was not understood. We must observe, however, that, as in many cases the effects of the bark are perceived soon after its being taken into the stomach, and before it can possibly be conveyed to the mass of blood, we may conclude, that its effects do not arise from its operating on the fluids; and must therefore depend upon its acting on the nerves of the stomach, and being thereby communicated to the rest of the nervous system. This operation seems to be a tonic power, the bark being a remedy in many cases of debility, particularly in gangrene; and if its operation may be explained from its possessing a tonic power, we may easily perceive why it is improper when a phlogistic diathesis prevails; and from the same view we can ascertain in what cases of continued fever it may be admitted. These cases are either where considerable remissions have appeared, when it may be employed to prevent the return of exacerbations, on the same footing as it is used in intermitting fevers; or in the advanced state of fevers, when all suspicion of an inflammatory condition is removed, and a general debility prevails in the system; and its being then employed is sufficiently agreeable to the present practice.

Typhus.

Another set of medicines to be employed for obviating debility and its effects, are the direct stimulants. These, in some measure, increase the tone of the moving fibres; but are different from the tonics, as they more directly excite and increase the action of the heart and arteries. This mode of operation renders their use ambiguous; and when an inflammatory diathesis is present, the effects of the stimulants may be very hurtful; but it is still probable, that in the advanced state of these fevers, when debility prevails, they may be useful.

Of all the stimulants which may be properly employed, wine seems to be the most eligible. It has the advantage of being grateful to the palate and stomach, and of having its stimulant parts so much diluted, that it can be conveniently given in small doses; and therefore it may be employed with sufficient safety.—It may be suspected that wine has an operation analogous to that of opium; and on good grounds. But we can distinctly remark its stimulant power only; which renders its effects in the phrenetic delirium manifestly hurtful; and in the mild delirium depending on debility, as remarkably useful.

[2.] We must now proceed to the other indication of cure, namely, to correct or obviate the tendency in the fluids to putrefaction. This may be done, 1. By avoiding any new application of putrid or putrescent matter. 2. By evacuating the putrid or putrescent matter already present in the body. 3. By correcting the putrid or putrescent matter remaining in the body by diluents and antiseptics. 4. By supporting the tone of the vessels, and thereby resisting further putrefaction, or obviating its effects. 5. By moderating the violence of reaction, considered as a means of increasing putrefaction.

The further application of putrid or putrescent matter may be avoided, 1. By removing the patient from places filled with corrupted air. 2. By preventing the accumulation of the patient's own effluvia, by a constant ventilation, and by a frequent change of bedclothes and body linen. 3. By the careful and speedy removal of all excremental matters from the patient's chamber. 4. By avoiding animal food.

The putrid or putrescent matter already present in the body, may be evacuated partly by frequent evacuations of the contents of the intestines; and more effectually still by supporting the excretions of perspiration

ration and urine by the plentiful use of diluents. That which remains in the body may be rendered more mild and innocent by the use of diluents, or may be corrected by the use of antiseptics. These last are of many and various kinds; but which of them are conveniently applicable, or more particularly suited to the case of fevers, is not well ascertained. Those most certainly applicable and useful are acescent aliments, particularly fruits, acids of all kinds, and neutral salts.

The progress of putrefaction may be considerably retarded, and its effects obviated, by supporting the tone of the vessels; and this may be done by tonic medicines, of which the chief are cold, and the Peruvian bark, as already mentioned. The violence of reaction increasing the tendency to putrefaction, may be moderated by the means already mentioned under *Synocha*.

These are the proper indications to be observed in the cure of the slow nervous fever; and they are chiefly fulfilled by cleanliness, cool air, and diluents; which, perhaps, upon the whole, are more useful in fevers, than all other practices put together. Dr Huxham observes, that evacuations (especially bleeding), are improper even at the beginning. Even a common purgative given at this time hath been followed by surprising languors, syncope, and a train of other ill symptoms. It may, however, sometimes be necessary to cleanse the stomach and primæ viæ by a gentle emetic, or a mild laxative. Indeed, where nausea, sickness and load at stomach are urgent, as is frequently the case in the beginning of this fever, a vomit is necessary. Clysters of milk, sugar, and salt, may be injected with safety and advantage every second or third day, if nature wants to be prompted to stool. The temperate, cordial, diaphoretic medicines, are certainly, according to our author, most proper in these fevers; and a well-regulated, supporting, diluting diet is necessary. The latter of itself, judiciously managed, will go a great way in the cure, especially if assisted by well-timed and well-applied blisters, and a due care to keep the patient as quiet as possible both in body and mind. But it should be noted, that strong opiates are commonly very pernicious, however much the want of sleep and restlessness may seem to demand them. Mild diaphoretics, such as neutral draughts or elixir paregoricum, have much better effects; which, by raising a gentle easy sweat, or at least a plentiful perspiration, calm the hurry of the spirits, and a refreshing sleep ensues. Where the confusion and dejection of spirits are very considerable, blisters have been advised to be applied to the neck, occiput, or behind the ears; and during all this a free use of thin wine whey, some pleasant ptisan or gruel, with a little pure wine, must be directed. Indeed the patients, in this case, should drink frequently; though such quantities may not be necessary as in the ardent or even putrid malignant fevers; yet they should be sufficient to carry on the work of dilution, support the sweats, and supply the blood with fresh and wholesome fluids, in place of that noxious matter which is continually passing off. In this view also a thin chicken broth is of service, both as food and physic, especially towards the decline of the disease; and for the same reason thin jellies of hartshorn, sago, and panada, are useful, adding a little wine to them, and the juice of orange or lemon.

Typhus.

It is observable, that the sick are never so easy as when they are in a gentle sweat; for this soon removes the hurry of spirits, exacerbations of heat, &c. But profuse sweats should never be encouraged, much less induced, by very strong heating medicines, especially in the beginning or advance of the fever; for they too much exhaust the vital powers, and are followed by a vast dejection of spirits, tremors, startings of the tendons, and sometimes end in rigors, cold clammy sweats, syncope, or a comatose disposition. Sometimes irregular partial heats and flushes succeed, with great anxiety, restlessness, delirium, difficulty of breathing, and a vast load and oppression in the præcordia, so as to incline the less cautious observer to think there may be something pneumonic in it; but even here we must beware of bleeding, as the pulse will be found very small and unequal, though very quick. Nor is bleeding contraindicated only by the weakness and fluttering of the pulse, but also by the pale, limpid, and watery urine which is commonly attendant. These symptoms denote the load, anxiety, and oppression on the præcordia to proceed from an affection of the nervous system, and not from a pneumonic obstruction or inflammation. The breathing in this case, though thick and laborious, is not hot, but a kind of sighing or sobbing respiration, nor is there often any kind of cough concomitant; so that it has been conjectured to proceed from some spasm on the vitals. Here therefore the nervous cordial medicines are indicated, and blisters to the thighs, legs, or arms.

The above-mentioned difficulty of breathing, anxiety, and oppression, many times precede a miliary eruption, which often appears on the seventh, ninth, or eleventh day of the fever, and sometimes later. Indeed great anxiety and oppression on the præcordia always precede pustular eruptions of any kind in all sorts of fevers. This eruption should be promoted by soft easy cordials and proper diluents; to which should be sometimes added some gentle aromatics. These tend to calm the universal uneasiness commonly complained of, and also very effectually promote a diaphoresis, with which the miliary eruptions freely and easily advance. But however advantageous these commonly are, profuse sweats are seldom or never so, even though attended with a very large eruption. Two or three crops of these miliary pustules have been known to succeed one another, following profuse sweats, not only without advantage, but with great detriment to the patients, as they were thereby reduced to an extreme degree of weakness; so that they justly may be reckoned symptomatic rather than any thing else, and the consequent eruption is often merely the symptom of a symptom.

In these profuse colliquative sweatings a little generous red wine (diluted somewhat, if necessary) may be given with the greatest advantage; as it presently moderates the sweats, supports the patient, and keeps up the miliary papulæ if they happen to attend. Towards the decline of the fever also, where the sweats are abundant and weakening, small doses of the tincture of cinchona with saffron and snakeroot may be given with the greatest advantage, frequently interposing a dose of rhubarb to carry off the putrid colluvies in the first passages; which withal makes the remissions or intermissions that often happen in the decline of nervous fevers

Febres. fevers more distinct and manifest, and gives a fairer opportunity of throwing in the bark; for in the proper exhibition of this medicine we are to place our chief hope of curing both the nervous and putrid malignant fevers.

166 II. Typhus gravior, or the *putrid, pestilential*, or *malignant* FEVER. Sp. I. var. 2.

Febris pestilens, *P. Sal. Divers.* de febre pestilenti.

Febris pestilens Ægyptiorum, *Alpin.* de med. Ægypt. l. i. cap. 14.

Typhus Ægyptiacus, *Sauv.* sp. 6.

Febris pestilens maligna, *Sennert.* de febribus, l. iv. cap. 10.

Febris maligna pestilens, *River*, l. xvii. sect. iii. cap. 1.

Febris pestilens maligna, ann. 1643, *Willis*, de febribus, cap. 14.

Typhus carcerum, *Sauv.* sp. 1.

Febris nautica pestilentialis, *Huxham* de aëre ad ann. 1740.

Miliaris nautica, *Sauv.* sp. g.

Febris putrida contagiosa in carceribus genita, *Huxham* de aëre ad ann. 1742.

Miliaris purpurata, *Sauv.* sp. h.

Febris carcerum et nosocomiorum. *Pringle*, Diseases of the army, p. 294. *Van Swieten*, Maladies des armés, p. 136.

Typhus castrensis, *Sauv.* sp. 5.

Febris castrensis, quam vulgò cephalalgiam epidemicam vocant, *Henr. Maii* et *A. Ph. Koph.* Diss. apud *Hallerum*, tom. v.

Febris Hungarica sive castrensis, *Juncker*, 74. et *plurium auctorum.*

Febris castrensis Gallorum in Bohemiâ, ann. 1742, *Scrinci.* Diss. apud *Haller.* tom. v.

Febris petechialis, *Sennert.* l. iv. cap. 13. *River.* prax. l. xvii. sect. iii. cap. 1. *Hoffm.* ii. p. 84. *Juncker*, 73. *Huxham* on fevers, chap. 8. *Ludwig.* Inst. med. clin. N° 146. *Schreiber* von erkentness, und cur der Krank heiten, p. 126. *Monro*, Diseases of military hospitals, p. 1.

Febris catarrhalis maligna petechizans, *Juncker*, 72. *Hoffm.* ii. 75. *Eller* de cogn. et cur. morb. sect. vi.

Febris quæ lenticulas, puncticula, aut peticulas vocant, *Fracastorius* de morb. contag. lib. ii. cap. 6.

Febris peticularis Tridenti, ann. 1591. *Roboretus* de febr. peticul.

Febris petechialis epidemica Coloniæ, ann. 1672. *Donckers*, Idia febris petechialis.

Febris petechialis epidemica Posonii, 1683, *C. F. Loeu* in App. ad A. N. C. vol. ii.

Febris petechialis epidemica Mutinæ, 1692. *Ramazzini.* Const. Mutinensis, oper. p. 177.

Febris maligna petechizans, ann. 1698. *Hoffm.* ii. p. 80.

Febris petechialis Wratislaviæ, ann. 1699. *Helwich*, Ephem. Germ. D. III. A. VII. et VIII. obs. 132. p. 616.

Febris epidemica Lipsiæ, 1718. *M. Adolph.* A. N. C. III. obs. 131. p. 296.

Febris endemica et epidemica Corcagiensis, ann. 1708, 1718, et seq. *Rogers*, Essay on Epidemic diseases.

Febris continua epidemica Corcagiensis, ann. 1719. et seq. *M. O'Connel*, Obs. de morbis.

Febris petechialis epidemica Cremonæ, 1734. *Valcarenghi* Med. ration. sect. 3.

Febris petechizans Petropoli, 1735. *Weitbrecht.* Diss. apud Haller. tom. v.

Febris petechialis, ann. 1740, 1741, in Hassia. *Ritter.* A. N. C. vol. vii. obs. 4.

Febris maligna petechialis Rintelli, 1741. *Furstenau*, A. N. C. vol. vii. obs. 5.

Febris petechialis epidemica Silesiæ, 1741, et seq. *Bandhorst.* Diss. apud *Haller.* tom. v.

Febris petechialis epidemica Viennæ, 1757. *Hasenohrl.* Hist. med. cap. 2.

Febris petechialis epidemica Lipsiæ, 1757. *Ludwig.* Adversar. tom. i. pars 1.

Febris petechialis epidemica variis Germaniæ locis ab ann. 1755 ad 1761. *Strack* de morbo cum petechiis.

Typhus.

Description. This disease has been supposed to differ from the former in degree only; and there are many circumstances which would lead us to conclude, that both frequently originate from a contagion precisely of the same nature. In the same manner we see, during different seasons, and in different circumstances, various degrees of malignity in smallpox. Though every instance of the disease depends on the introduction of a peculiar and specific contagion into the body, yet this contagion in particular epidemics evidently possesses peculiar malignancy. The same is probably the case with the typhoid fever: But whether this observation be well founded or not, there cannot be a doubt that the typhus gravior or putrid fever is a disease of the most dangerous nature, as, besides the extreme debility of the nervous system, there is a rapid tendency of the fluids to putrefaction, which sometimes cuts off the patient in a few days, nay, in the warm climates, in 12 or 14 hours; or if the patient recovers, he is for a long time, even in this country, in an exceeding weak state, and requires many weeks to recover his former health.

The putrid fevers, according to Huxham, make their attack with much more violence than the slow nervous ones; the rigors are sometimes very great, though sometimes scarce felt; the heats much sharper and permanent; yet, at first, sudden, transient, and remittent: the pulse more tense and hard, but commonly quick and small; though sometimes slow, and seemingly regular for a time, and then fluttering and unequal. The headach, nausea, and vomiting, are much more considerable even from the beginning. Sometimes a severe fixed pain is felt in one or both temples, or over one or both eyebrows; frequently in the bottom of the orbits of the eyes. The eyes always appear very dull, heavy, sometimes yellowish, and very often a little inflamed. The countenance seems bloated, and more dead-coloured than usual. Commonly the temporal arteries throb much, and a tinnitus aurium is very troublesome: a strong vibration also of the carotid arteries frequently takes place in the advance of the fever, though the pulse at the wrist may be small, nay even slow: this is a certain sign of an impending delirium,

rium, and generally proceeds from some considerable obstructions in the brain.

The prostration of spirits, weakness, and faintness, are often surprisingly great and sudden, though no inordinate evacuation happens; and this too sometimes when the pulse seems tolerably strong. The respiration is most commonly laborious, and interrupted with a kind of sighing or sobbing, and the breath is hot and offensive.

Few or none of these fevers are without pain in the back and loins; always an universal weariness or soreness is felt, and often much pain in the limbs. Sometimes a great heat, load, and pain, affect the pit of the stomach, with perpetual vomiting of porraceous or black bile, and a most troublesome singultus; the matter discharged is frequently of a very nauseous smell. The tongue, though only white at the beginning, grows daily more dark and dry; sometimes of a shining livid colour, with a kind of dark bubble at top; sometimes exceeding black; and so continues for many days together; nor is the tinct to be got off many times for several days, even after a favourable crisis: at the height of the disease, it generally becomes very dry, stiff, and black, or of a dark pomegranate colour. Hence the speech is very inarticulate, and scarce intelligible. The thirst in the increase of the fever is commonly very great, sometimes unquenchable; and yet no kind of drink pleases, but all seem bitter and mawkish; at other times, however, no thirst is complained of, though the mouth and tongue are exceedingly foul and dry; this is always a dangerous symptom, and ends in a frenzy or coma. The lips and teeth, especially near the height, are covered with a very black tenacious sordes. At the commencement of the fever, the urine is often crude, pale, and vapid, but grows much higher coloured in the advance, and frequently resembles a strong lixivium, or citrine urine, tinged with a small quantity of blood; it is without the least sediment or cloud, and so continues for many days together: by degrees it grows darker, like dead strong high-coloured beer, and smells very rank and offensive. In petechial fevers, the urine has often been seen almost black and very *fetid*. The stools, especially near the height, or in the decline of the fever, are for the most part intolerably fetid, green, livid, or black, frequently with severe gripes and blood. When they are more yellow or brown, the less is the danger; but the highest when they run off insensibly, whatever their colour may be. It is likewise a very bad symptom when the belly continues tense, swollen, and hard, after profuse stools; for this is generally the consequence of an inflammation or mortification of the intestines. A gentle diarrhœa is often very beneficial, and sometimes seems to be the only way which nature takes to carry off the morbific matter.

Sometimes black, livid, dun, or greenish spots appear on different parts of the skin, particularly on the breast, which always indicate a high degree of malignity; but the more florid the spots are, the less danger is to be feared. It is also a good sign when the black or violet petechiæ become of a brighter colour. The large, black, or livid spots, are almost always attended with profuse hæmorrhagies; and the small, dusky, brown spots, like freckles, are not much less dangerous than the livid or black; though they are seldom accompanied with fluxes of blood: excessively profuse, cold, clammy sweats are often concomitant, by which also they sometimes vanish, though without any advantage to the patient. The eruption of the petechiæ is uncertain; sometimes they appear on the fourth or fifth day, though sometimes not till the eleventh, or even later. The *vibices*, or large dark blue or greenish marks, seldom appear till very near the fatal period. Frequently also we meet with an efflorescence like the measles in malignant fevers, but of a much more dull and livid hue; in which the skin, especially on the breast, appears as it were marbled or variegated. This in general is an ill symptom, and is often attended with fatal consequences.

Sometimes about the 11th or 14th day, on the occurrence of profuse sweats, the petechiæ disappear, and vast quantities of white miliary pustules break out. This is seldom found of any considerable advantage; but an itching, smarting, red rash, commonly gives great relief; and so do the large, fretting, watery bladders, which many times rise upon the back, breast, shoulders, &c. A scabby eruption likewise about the lips and nose is one of the salutary symptoms; and the more hot and angry it is, so much the better. But of much more uncertain and dangerous event are the brown-coloured aphthæ; nor are those that are exceeding white and thick, like lard, of a very promising aspect. They are soon succeeded by great difficulty of swallowing, pain and ulceration of the fauces, œsophagus, &c. and with an incessant singultus: the whole *primæ viæ* become at last affected; a bloody dysentery comes on, followed by a sphacelation of the intestines; as is evident from the black, sanious, and bloody stools, extremely fetid and infectious. Vibices, or large black and bluish marks resembling bruises, are frequently seen towards the close of the fever; and, when attended with lividity and coldness of the extremities, are certain tokens of approaching death. In some cases, the blackness has been known to reach almost to the elbows, and the hands have been dead-cold for a day or two before the death of the patient.

Such are the general appearances of the putrid malignant fever in this country, among those who enjoy a free air, and are not crowded together, or exposed to the causes of infection: but in jails, hospitals, or other places where the sick are crowded, and in some measure deprived of the benefit of the free air, the symptoms are, if possible, more terrible. Sir John Pringle, who had many opportunities of observing it, tells us, that the jail or hospital fever, in the beginning, is not easy to be distinguished from a common fever. The first symptoms are slight interchanges of heat and cold, a trembling of the hands, sometimes a sense of numbness in the arms, weakness of the limbs, loss of appetite; and the disorder increasing towards night, the body grows hot, the sleep is interrupted, and not refreshing. With these symptoms, for the most part, there is some pain or confusion in the head; the pulse at first is a little quicker than natural, and the patients find themselves too much indisposed to go about business, though too well to be wholly confined. When the fever advances, the above-mentioned symptoms are in a higher degree; and in particular the patient

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patient complains of a lassitude, nausea, pains in his back, a more constant pain and confusion in his head, attended with an uncommon dejection of spirits. At this time the pulse is never sunk, but beats quick, and often varies in the same day both as to strength and fulness. It is little affected by bleeding, if a moderate quantity of blood be taken away; but if the evacuation be large, and especially if it be repeated, to answer a false indication of inflammation, the pulse, increasing in frequency, is apt to sink in force, and often irrecoverably, whilst the patient becomes delirious. But we must observe, that, in every case, independent of evacuations, the pulse sooner or later sinks, and then gives certain evidence of the nature of the disease. The appearance of the blood is various; for though it be commonly little altered, yet sometimes it will be sizy, not only on the first attack, but after the fever is formed. The worst appearance is when the crassamentum is dissolved; though this does not happen till the advanced state of the fever: indeed this seems not easy to be ascertained, as blood has been so seldom taken away at that time. The urine is also various. Sometimes it is of a reddish or flame colour, which it preserves a long time; but it is oftener pale, and changes from time to time in colour as well as crudity, being sometimes clear, sometimes clouded: towards the end, upon a favourable crisis, it becomes thick, but does not always deposit a sediment. If the sick lie warm, and have had no preceding flux, the belly is generally bound; but when they lie cold, as they often do in field-hospitals, the pores of the skin being shut, a diarrhœa is a common symptom, but is not critical. In the worst cases, a flux appears in the last stage; then the stools are involuntary, colliquative, ichorous, or bloody, and have a cadaverous smell; the effects of a mortification of the bowels, and the sign of approaching death. When the hospitals are filled with dysenteric patients, some of the nurses will be infected with the flux only, and others with this fever, ending in these bloody and gangrenous stools.

In the beginning the heat is moderate; and even in the advanced state, on first touching the skin, it seems inconsiderable: but upon feeling the pulse for some time, we are sensible of an uncommon heat (the *calor mordicans*, as it has been called), leaving an unpleasant sensation on the fingers for a few minutes. A day or two before death, if care be not taken, the extremities become cold, and the pulse is then hardly to be felt. The skin is generally dry and parched; though sometimes there are longer or shorter sweats, especially in the beginning. Such as are produced by medicine are of no use, except on the first attack, at which time they will often remove the fever; and natural sweats are never critical till the distemper begins to decline. These last are rarely profuse, but gentle, continued, and equally diffused over the body: sometimes the disease will terminate by an almost imperceptible moisture of the skin; the sweats are usually fetid, and offensive even to the patient himself.

The tongue is commonly dry; and, without constant care of the nurse, becomes hard and brown, with deep chops: but this symptom is common to most fevers. At other times, though rarely, the tongue is soft and moist to the last, but with a mixture of a greenish or yellowish colour. The thirst is sometimes great, but more frequently moderate. In the advanced state, the breath is offensive, and a blackish furring gathers about the roots of the teeth.

Some are never delirious, but all lie under a stupor or confusion; few retain their senses till death: many lose them early, and from two causes; either from immoderate bleeding, or the premature use of warm and spirituous medicines. They rarely sleep; and, unless delirious, have more of a dejected and thoughtful look than what is commonly seen in other fevers. The face is late in acquiring either a ghastly or a very morbid appearance; yet the eyes are always muddy, and generally the white is of a reddish cast as if inflamed. The confusion of head commonly rises to a delirium, especially at night; but, unless by an unseasonable hot regimen, it seldom turns to rage, or to those high flights of imagination common in other fevers. When the delirium comes to that height, the face is flushed, the eyes red, the voice is quick, and the patient struggles to get up. But when that symptom is owing to large evacuations, or only to the advanced state of the disease, the face appears meagre; the eye-lids in slumbers are only half shut; and the voice, which is commonly low and slow, sinks to a degree scarce to be heard. From the beginning there is generally a great dejection and failure of strength. A tremor of the hands is more common than a starting of the tendons; and if the subsultus occurs, it is in a lesser degree than in many other fevers. In every stage of the disease, as the pulse sinks, the delirium and tremors increase; and in proportion as the pulse rises, the head and spirits are relieved. Sometimes in the beginning, but for the most part in the advanced state, the patient grows dull of hearing, and at last almost deaf. When the fever is protracted, with a slow and low voice, the sick have a particular craving for something cordial, and nothing is so cordial or so acceptable as wine. They long for no food, yet willingly take a little panada if wine be added. But such as are delirious, with a quick voice, wild looks, a subsultus tendinum, or violent actions, though their pulse be sunk, yet bear neither hot medicines, wine, nor the common cordials.

Vomiting, and complaints of a load and sickness at stomach, though usual symptoms, are not essential to the disease; nor are pleuritic stitches, difficulty in breathing, or flying pains, to be referred so much to it as to the constitution of the patient, or to a preceding cold.

A petechial efflorescence is a frequent, though not an inseparable, attendant of this fever. It sometimes appears of a brighter or paler red, at other times of a livid colour, but never rises above the skin. The spots are small; but generally so confluent, that at a little distance the skin appears only somewhat redder than ordinary, as if the colour was uniform; but upon a nearer inspection interstices are seen. For the most part this eruption is so little conspicuous, that unless it be looked for attentively, it may escape notice. The spots appear thickest on the back and breast, less on the legs and arms, and Sir John Pringle never remembers to have seen any on the face. As to the time of their appearance, he agrees entirely with Dr Huxham. These spots are never critical, nor are they reckoned among the mortal symptoms; but only concur with other signs to ascertain the nature of the disease. The nearer they

they approach to purple, the more they are to be dreaded. In a few cases, instead of spots, purple streaks and blotches were observed. Sometimes the petechiæ did not appear till after death; and there was one case in which, after bleeding, the petechiæ were seen only on the arm below the ligature, and nowhere else on the skin.

The hospital fever, though accounted one of the continued kind, yet has generally some exacerbations at night, with a remission and often partial sweats in the day; and after a long continuance it is apt to change into a hectic, or an intermitting form. The length of the disease is uncertain. Sometimes it was terminated, either in death or recovery, in seven days after the patient took to his bed: but in the hospitals it generally continued from 14 to 20, and some died or recovered after four weeks. From the time of the sinking of the pulse until death or a favourable crisis, there is perhaps less change to be seen from day to day in this than in most other fevers. When its course is long, it sometimes terminates in suppurations of the parotid or axillary glands; and when these do not appear, it is probable that the fever is kept up by the formation of some internal abscess. The parotid glands themselves do not suppurate, but only some of the lymphatic glands that lie over them. Sir John Pringle observed one instance of a swelling of this kind on both sides, without any previous indisposition, when the person, not suspecting the cause, and applying discutient cataplasms, was, upon the tumour subsiding, seized with the hospital-fever. Many patients after the crisis of this fever complain of a pain in the limbs and want of rest; and almost all of them mention great weakness, confusion in their head, vertigo, and a noise in their ears.

Ten of the bodies of those who died of this distemper in Houghton's regiment were opened. In some, all the cavities were examined; in others, only the brain and the bowels. In some of them, the brain appeared to be suppurated. The first of this kind Sir John Pringle met with at Ghent; but the man being brought into the hospital from the barracks no earlier than two days before he died, he could only conjecture from the symptoms and the imperfect accounts he had of him, that his death was owing to a fever of this kind, after lingering near a month in it. About three ounces of purulent matter were found in the ventricles of the brain, and the whole cortical and medullary substance was uncommonly flaccid and tender; nay, some of the same kind of matter was found in the substance of the upper part of the cerebellum: yet this person, with some stupor and deafness, had his senses till the night before he died; so far, at least, that he answered distinctly when roused and spoken to; but about that time the muscles of his face began to be convulsed. Of two other instances of men who undoubtedly died of this fever, in one the cerebrum was suppurated, in the other the cerebellum. In the former case, the patient was under a stupor, with deafness from the beginning; but was never delirious, nor altogether insensible. His pulse sunk early; and about ten days before his death his head began to swell, and continued very large till within two days before he died, when it subsided a little. For several days before his end, he would taste nothing but cold water, and during his illness he lay constantly upon one side. The head being opened, an abscess as large as an egg was found in the substance of the fore-part of the right hemisphere of the brain, full of thin matter like whey. At that time five more, ill of the same fever, had the like swelling of their heads, but recovered. In the other case, the abscess in the cerebellum was about the size of a small pigeon's egg, and contained also a thin ichorous matter; nor had this patient ever been so thoroughly insensible as not to answer reasonably when spoken to. Two days before he died his urine turned pale.

These suppurations, however, were not constant; for another who died about the same time, and had been ill about the same number of days with the like symptoms, the pale water excepted, had no abscess either in the brain or cerebellum. Two were opened afterwards, in whom the cortical substance of the brain had an inflammatory appearance, but no suppuration. In one of them the large intestines were corrupted; that man went off with a looseness; and just before he died, an ichorous matter was discharged from his nose. In the military hospital at Ipswich, one who unexpectedly died of this fever after having been seemingly in a fair way of recovery, had no suppuration in his brain; but in another, who died after an abscess in both orbits, the brain was found flaccid, and about tw ounces of a thin serum in the ventricles.

Causes of, and persons subject to, this disorder. The cause of this fever, as well as that of the slow nervous fever, is an infection or contagion from some diseased animal-body, or from corrupted vegetables; and therefore is very little, if at all, different from those pestilential disorders which have arisen after battles, where great numbers of dead bodies were allowed to lie above ground, and infect the air with their effluvia. This is confirmed by an observation of Forestus, who was eye-witness to a distemper of this kind (which indeed he calls a *plague*) owing to the same cause, attended with buboes and a high degree of contagion. The same author also gives an account of a malignant fever breaking out at Egmont in North-Holland, occasioned by the rotting of a whale which had been left on the shore. We have a like observation of a fever affecting the crew of a French ship, by the putrefaction of some cattle which they had killed on the island of Nevis in the West Indies. These men were seized with a pain in their head and loins, great weakness, and a disorder of the stomach, accompanied with fever. Some had carbuncles; and on others purple spots appeared after death.

Galen assigns two causes for pestilential fevers: 1. The great heat of the weather, when the humours happen to be in a more putrescent state than usual. 2. A putrid state of the air, arising either from a multitude of dead bodies left unburied, as after a battle, or from the evaporation of corrupted lakes and marshes.

One of the most remarkable diseases incident to an army is related by Diodorus, as breaking out among the Carthaginians at the siege of Syracuse. That author not only relates some of its most distinguishing symptoms, but reasons well about its cause. He observes, that pains in the back and eruptions (φλυκταιναι) were common; that some had bloody stools; that others were seized with a delirium, so as to run about and beat all that came in their way; that the physi-

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cians knew no cure; and that it was the more fatal as the sick were abandoned by every body on account of the contagion. As to the cause, the author takes notice of the multitude of people confined within a narrow compass; of the situation of the camp in low and wet ground; of the scorching heats in the middle of the day, succeeded by the cold and damp air from the marshes in the night time; to these he adds, the putrid steams arising from the marshes, and afterwards from the bodies of those who lay unburied.—This distemper seems to have been a compound of the marsh and pestilential fever.

Forestus remarks, that, from the putrefaction of the water only, the city of Delft, where he practised, was scarce ten years together free from the plague or some pestilential distemper. He adds, that the magistrates, upon his representation of the cause, erected a wind-mill for moving and refreshing the water. At that time Holland was much more subject to inundations and the stagnation of water than at present. In 1694, a fever broke out at Rochfort in France, which, on account of the uncommon symptoms and great mortality, was at first believed to be the plague. But M. Chirac, who was sent by the court to inquire into its nature, found the cause to arise from some marshes that had been made by an inundation of the sea; and observed, that the corrupted steams, which smelled like gun-powder, were carried to the town by the wind, which had long blown from that quarter. About two thirds of those who were taken ill died. In such as were opened, the brain was found either inflamed or loaded with blood; the fibres of the body were uncommonly tender; and the bowels had either suppurated or were mortified.

It is needless to mention more instances of pestilential fevers being brought on by the steams of corrupted substances, whether animal or vegetable. In general it may be remarked, that the putrefaction of these substances in a dry air is more apt to bring on a fever of the continued form; but in a moist air has a greater tendency to produce remitting fevers. But it must also be observed, that, even in cases where the most malignant fevers prevail, all persons are not equally disposed to receive the infection, though equally exposed to it with others. Some, through mere vigour of body and mind, cannot be infected with the most contagious diseases; while, on the other hand, those whose bodies are debilitated by a former disease, by study, low diet, or want, or those who have laboured under any of the depressing passions of the mind for some time, seldom or never escape. Men, therefore, who have been weakened by accidents (as those who have undergone a mercurial salivation) are very apt to fall into this distemper. Those who are taken into crowded hospitals, ill of the smallpox, however good the sort may be, fall readily into this fever, and run a greater risk of dying of it than others. The second fever is attended with double danger, seeing the patient has been so much weakened by the first. A sure sign of the corruption of the air in an hospital is when many of the nurses fall sick.

Prognosis. In these fevers we cannot draw a prognostic from any symptom by itself; and perhaps all of them together are more fallible than in others. Generally the following are good: To have little delirium; the strength little impaired; turbid urine in the decline of the disease; and at that time a gentle sweat or moisture diffused over the body, or even the skin soft and the tongue moist; or to have some loose stools succeeded by a diaphoresis; the pulse to rise by wine or cordials, with an abatement of the stupor, tremor, and other affections of the brain. Deafness is rather a good sign. A sediment in the urine, without other changes for the better, is no sure sign of recovery; and some have recovered in whose urine there was no sediment.—The bad signs are, a subsultus tendinum; the eyes much inflamed and staring; the speech quick, and the sound of the voice altered; a high delirium; perpetual watchfulness; constant sickness at the stomach, and vomitings; frequent stools, with a sinking pulse, and the disorder of the head increased; coldness of the extremities, and a tremulous motion of the tongue. It is observed to be among the worst signs when the patient complains of blindness; when he swallows with difficulty, or cannot put out his tongue when desired to do it; when he can lie on his back only, and pulls up his knees; or when insensible he endeavours to uncover his breast, or makes frequent attempts to get out of bed without assigning any reason. If to any of these are added ichorous, cadaverous, and involuntary stools, it is a sign of a mortification of the bowels and approaching death. It will not seem strange to find most of these prognostics common to the advanced state of other fevers, when we consider, that from whatever cause fevers begin, by a long continuance the humours are corrupted, and the brain and nerves affected much in the same manner as in those which arise from infection.

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Prevention and cure. As distempers of the putrid kind never arise without an infection received from some quarter or other, the method of prevention must evidently be reduced to two general heads. 1. To avoid receiving the infection into the body; and, 2. To put the body in such a situation as may enable it to resist the infection when received. On both these methods scarce any writer hath equalled Dr Lind of Haslar, whose opinions and directions therefore we shall give pretty fully.

As putrid diseases are very common and violent in the hot countries, it is very necessary for Europeans who visit these climates to be well informed, in the first place, of the signs of an unhealthy country, that they may be upon their guard as soon as they enter any foreign region. These signs are by this author enumerated as follows.

1. A sudden and great alteration in the air, at sunset, from intolerable heat to a chilling cold. This is perceived as soon as the sun is down, and is for the most part accompanied with a very heavy dew: it shows an unhealthy swampy soil, the nature of which is such that no sooner the sun-beams are withdrawn, than the vapours emitted from it render the air damp, raw, and chilling, in the most sultry climates; so that even under the equator, in some unhealthy places, the night-air is very cold to an European constitution.

2. Thick noisome fogs, chiefly after sunset, arising from the valleys, and particularly from the mud, slime, or other impurities. In hot countries, the smell of these

these fogs may be compared to that of a new-cleaned ditch. Diseases, therefore, arising from this cause, generally take place in the night, or before sunrising.

3. Numerous swarms of flies, gnats, and other insects which attend stagnated air and unhealthy places covered with wood.

4. When all butchers meat soon corrupts, and in a few hours becomes full of maggots; when metals are quickly corroded on being exposed to the air; and when a corpse becomes intolerably offensive in less than six hours; these are proofs of a close, hot, and unwholesome country. And in such places, during excessive heats and great calms, it is not altogether uncommon for Europeans, especially such as are of a gross habit of body, to be seized at once with the most alarming and fatal symptoms of what is called the *yellow-fever*, without even any previous complaint of sickness or other symptoms of the disease. There has first been perceived an uneasy itching sensation, commonly in the legs; and upon pulling down the stockings, streams of thin dissolved blood followed, a ghastly yellow colour quickly diffused itself over the whole body, and the patient has been carried off in less than forty-eight hours.

5. A sort of sandy soil, commonly a small, loose, white sand, as that at Pensacola, Whydah, and the island of Bonavista, which is found by experience to be injurious to health. The pestiferous vapour arising, during the summer months and in the heat of the day, from such a sandy soil, is best characterized by its effects in the extensive deserts of Asia and Africa. It there constitutes what is called the *Samiel-wind;* a blast which, in the parched desert, proves instantly fatal both to man and beast; but when it passes over a soil well covered with grass and vegetables, has its effects greatly mitigated; it is, however, even then, productive of sickness: thus the southerly winds, while they blow from the deserts of Libya during the summer, at Algiers, Tunis, and Tripoli, produce an unhealthy season; and at Madras the winds, which, in the months of April and May, pass over a large tract of sand, are always hot, disagreeable, and unwholesome.

During these land-winds, sudden gusts of a more hot and suffocating nature are often observed to come from these sands once or twice, or even more frequently, in a day, which seem to be this vapour in a purer form. These gusts pass very quickly, and affect persons who happen to stand with their faces towards them in the same manner as the hot air which issues from a burning furnace, or from a heated oven, and obliges them immediately to turn away from it in order to recover breath. The effect of this hot suffocating blast or vapour on the human body, even when mitigated by passing through a moist atmosphere, is the same as that of intense cold; it shuts up every pore of the skin, and entirely stops the perspiration of such as are exposed to it. These blasts come only in the daytime, and always from the deserts. Water is the only known corrector or antidote against them: hence, coarse thick cloths, kept constantly wet, and hung up at the windows or doors, greatly mitigate their violence. A house so built as to have no windows or doors towards the deserts, is an excellent protection against their pernicious effects. The hot land-winds constantly blow at Madras and other places on the coast of Coromandel, at that season, from midnight till noon; the sea-breezes then begin, which relieve the difficulty in breathing, and the obstructed perspiration, which the former occasioned.

That the heat of these land-winds, as also of the sudden gusts which accompany them, proceeds from large tracts of sand heated by the sun, is evident from the increased heat and suffocating quality of those winds, in proportion as the day advances, and as the heat of the season is increased. The opposite winds, blowing from each side of the Balagate mountains, are a further proof of this. These mountains running from north to south, divide the Hither Peninsula of India into two equal parts, and separate what is called the *Malabar* from the *Coromandel* coast. To the former they are very near, but at a great distance from the latter. The winds blowing from those hills are on the Malabar coast always remarkably cool; but on the coast of Coromandel, in the months of April, May, June, and July, are extremely hot and suffocating, as they pass over a large tract of intermediate sand, heated during those months by an almost vertical sun. Hence the Malabar coast is always covered with an agreeable verdure; whereas the Coromandel coast, during the continuance of these hot winds, seems a barren wilderness, nothing appearing green except the trees. On the contrary, the winds that pass over these sands, after being wet with the rains, are the coldest which blow at Madras. Bottles of liquor inclosed in bags of coarse cloth, kept constantly wet, and suspended in the shade, where those hot winds may have access to them, become as cold as if they had been immersed in a solution of nitre; an effect owing undoubtedly to the constant evaporation of water from the surface.

It is an observation of the natives on the coast of Coromandel, which is confirmed by the experience of many Europeans, that the longer the hot land-winds blow, the healthier are the ensuing months; these winds, as they express it, purifying the air. Are not the winds therefore the cause why the air on the coast of Coromandel, except during their continuance, is more healthy than in other parts of India where these winds do not blow? Does not this also suggest a very probable reason, why the plague in Egypt generally ceases in the beginning of June; the periodical hot winds which come from the deserts of Nubia and Ethiopia having then rendered the air of Egypt pure and wholesome? Many have ascribed that effect to the north winds; as the plague not only ceases when they blow, but all infected goods, household-furniture, and wearing apparel, are then said to become entirely free from the contagion: these, however, cannot be the cause, as the most destructive plague is abated in its violence, if not wholly eradicated, before they set in. With equal propriety we may reject the opinion that the overflowing of the Nile is productive of that salutary effect, as the plague generally ceases before the increase of that river is perceptible.

Thus the plague, the greatest calamity which can afflict mankind, seems to be destroyed by those hot winds, which are otherwise so pernicious to animal and vegetable life. And although, during the continuance of these winds, the most fruitful fields wear the

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the aspect of a parched desert, yet no sooner the rains fall, but vegetation is restored, the plants revive, and a beautiful verdure is again spread over the face of the country.

Having thus given an account of the signs of an unhealthy country, Dr Lind next proceeds to mention such employments as are particularly dangerous to Europeans on their first arrival. One of these is the cutting down of trees, shrubs, &c. or *clearing the ground*, as it is called. Of the unhealthiness of this employment he gives two instances. At the conclusion of the late peace, the captain of a ship of war went on shore at the island of Dominica, with 12 of his men, to cut down the wood, and to clear a piece of ground which he intended to have purchased: but, in a few days, sickness obliged him to desist from this dangerous work; the captain and 11 of his men being seized with violent fevers, which terminated in obstinate intermittents, and of which several died. The survivors suffered so much in their constitutions, that, even after they came to England, the return of an east-wind was apt to bring on a violent fit of the ague. The Ludlow-Castle, a ship of war of 40 guns, in a voyage to the coast of Guinea, also lost 25 of her men at Sierra Leona, who were employed in cutting down wood for the ship. This is an occupation which has often proved destructive to Europeans in those climates, and in which they ought never to be employed, especially during the rainy season; there being numberless instances of white persons, when cutting down the woods at that season, who have been taken ill in the morning, and dead before night.

Another evil, less known, and less suspected, but no less dangerous, is the sending Europeans in open boats after sunset, where the soil is swampy, or where there are great night-fogs. The single duty alone of fetching fresh-killed butchers meat at night for the use of our ships companies in the East and West Indies, has destroyed every year several thousand seamen. In those parts of the world, butchers meat must be brought on board at night immediately after it is killed, otherwise it will not be fit for use the next day; but a contract made with the natives to send it on board at that time, which might be done for a trifling sum, would be the means of preserving many useful lives. During the sickly season at Batavia, a boat belonging to the Medway, which attended on shore every night, was three times successively manned, not one having survived that service. They were all taken ill in the night, when on shore, or when returning on board; so that at length the officers were obliged to employ none but the natives on that business. Great numbers of men have perished from being employed in this manner at Bengal, where the European ships often anchor in the most unhealthy spots of the river; and even when the great night-fogs arise, after the rainy season, the men are often obliged to perform such night-services in boats. Now since it is so dangerous for Europeans in unhealthy countries, particularly during a season of sickness, to be exposed in an open boat to the foggy night-air, it must appear that sending them unsheltered, in open boats, far up rivers, in unhealthy southern climates, for the sake of wood, water, trade, or other purposes, must be attended with the most destructive and fatal consequences.

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Burying the dead in swampy countries is another occupation which has proved fatal to many, and which ought to be entrusted to negroes or the natives of the country. The effluvia from the ground when newly opened, whether from graves or ditches, are far more dangerous than from the same swampy soil when the surface is undisturbed; nay, in some places, it has been found almost certain death for an European to dig a grave, unless long seasoned to the country. In such a place, the attendance of friends at funerals ought to be dispensed with.

In all cases where it is practicable, the ships which visit these unhealthy countries should anchor at as great a distance as possible from shore; or if obliged to anchor near marshy grounds or swamps, especially during summer or in hot weather, and when the wind blows directly from thence, the gun-ports which would admit the noxious land-breeze ought to be kept shut, especially at night. Or if the ship rides with her head to the wind, a thick sail ought to be put upon the fore-mast, along which the smoke from the fire-place might be made constantly to play and ascend. If the sail should occasion a little smoke between decks, this inconvenience will be sufficiently compensated by its keeping off the direct stream of the swampy shore effluvia; which now being obliged to form a curve before they reach the more distant parts of the vessel, must needs be greatly diverted and scattered.

The best preservative against the mischievous impressions of a putrid fog, or of a marshy exhalation, is a close, sheltered, and covered place; such as the lower apartments in a ship, or a house in which there are no doors or windows facing the swamps. If in such places a fire be kept either at the doors and other inlets to a house, or in the chambers, as is practised in some unhealthy countries during the rainy or foggy season, it will prove an excellent and effectual protection against the injuries of a bad air. On board of ships also fires may be made at the hatchways; and of the good effects of this we have the following example. When the Edgar, a ship of war of 60 guns, was upon the coast of Guinea in the year 1768, her men were very sickly, and many of them died: however it was observed, that in a sloop of war, which was constantly in company with her, few were taken ill, and not one died during the whole voyage. This could be ascribed to no other cause, but that in the sloop the fire-place for cooking victuals was on the same level with the deck where the men lay; and every morning when the fire was lighted, especially when there was but little wind, the smoke from the cook-room spread itself all over the ship, and particularly over those parts where the men lay; but from the construction of the fire-place of the Edgar, no smoke from it ever came between her decks.

Persons on board any ship whatever, are much more safe, and their situation is much preferable to that of those who make distant inland excursions in small boats upon the rivers, and who are for the most part ignorant of the cause of those maladies which destroy them. The intolerable heat at noon often obliges such persons to go in a manner half naked; while a free and plentiful perspiration issues from every pore. A near approach to putrid swamps at this time is apt to produce an immediate sickness, vomiting, and afterwards

afterwards a low nervous or malignant fever. If they happen to pass them at night, or lie near them in an open boat, the air from those swamps is perceived to be quite chill and cold; in so much that warm thick clothing becomes absolutely requisite to guard the body against the impressions of so great an alteration in the air, and against its cold and inclement quality: for the effects of it then, even on the most healthy and vigorous constitution, is frequently a chilling cold fit of an ague, terminating in a fever with delirium, bilious vomitings, and purging, or even death itself.

Where such exposure becomes unavoidable, the only method is to defend the body as much as possible against the pernicious miasmata with which the air abounds.—All those who are employed in cutting down woods, or in other laborious and dangerous services in hot climates, during the heat of the day, ought to have their heads covered with a bladder dipt in vinegar, and to wash their mouths often with the same liquor; never to swallow their spittle, but rather to chew a little rhubarb or some other bitter, and spit it out frequently; to stop their nostrils with a small bit of linen or tow dipped in camphorated vinegar; and to infuse some Peruvian bark, garlic, and rhubarb, in brandy, of which a dram is to be taken, either by itself or diluted with water, morning and evening.

In the evening before sunset they should leave off work, and not return to their labour in the morning till the sun has dispersed the unwholesome dews and vapours. Those who must of necessity remain on shore, and sleep in dangerous places, should take care not to sleep upon the ground exposed to the dews, but in hammocks in a close tent, standing upon a dry sand, gravel, or chalk, near the sea shore, and where there is no subterraneous water for at least four feet below the surface of the ground. The door of this tent should be made to open towards the sea; and the back part of it, which receives the land breeze, must be well secured by double canvas, or covered with branches of trees. But in such circumstances, a hut, when it can be procured, is preferable to a tent, especially if it be well thatched, so as to prove a defence both against the excessive heat of the sun by day, and the noxious dews which fall at night. Here the men may be enjoined to smoke tobacco. When the air is thick, moist, and chill, the earth being overspread with cold dew, a constant fire must be kept in and about the tent or hut, as the most excellent means of purifying such unwholesome air, and of preserving the health of those who either sleeping or waking are exposed to its influence. The centinels who guard the water-casks, ought likewise at such a time to have a fire burning near them. All old and forsaken habitations, natural caves and grottos in the earth, where the men may be induced to take up their abode, must before their admission be perfectly dried and purified with sufficient fires. Fire and smoke are undoubtedly the great purifiers of all tainted and unwholesome air, and the most excellent preservatives against its noxious influence. It is the custom of the negroes in Guinea, and also of some Indians (who both sleep for the most part on the ground), to have a fire, producing a little smoke, constantly burning in their huts where they sleep. This not only corrects the moisture of the night, but also, by occasioning more smoke than heat, renders the damp from the earth less noxious; of which Dr Lind gives the following remarkable instance. A Guinea ship being up one of the rivers for the sake of trade, it was found to be very dangerous to sleep on shore: without which their trade could not be so conveniently carried on. First the captain, then the mate, and two or three of the seamen, were taken ill; each of them the morning after they had lain on shore. By these accidents the men were greatly intimidated from lying ashore; till the surgeon boldly offered to try the experiment on himself. Next morning when he waked, he found himself seized, as the rest, with a giddiness and pain in the head. He immediately acquainted one of the negroes with his condition, who carried him to his hut, and set him down in the smoke of it; when his shiverings and giddiness soon left him. He then took a dram of the bark bitter; and found himself greatly relieved, especially by breathing some time in the smoke.—Thus instructed by the negro, he ordered a large fire to dry the hut he slept in; and afterwards had every night a small fire sufficient to raise a gentle smoke without occasioning a troublesome heat: and by this means he and several others, using the same precautions, slept many nights on shore without any inconvenience.

Fire and smoke indeed are found to be certain correctors, or rather destroyers, of infection in all cases, whether arising from the noxious effluvia of marshes, or from the contagion of diseased bodies. Even those most extraordinary and fatal damps called *harmattans*, are unable to resist the salutary effects of smoke. In other cases, Dr Lind remarks, that, under some circumstances, the source of an infection in a sick chamber, or any other place, may be removed or destroyed by accidental means, for which we cannot account, and which we often cannot ascertain. But it oftener happens, that it is very difficultly rooted out; and, that exact cleanliness, with the benefit of a pure air, often proves insufficient to remove the evil. Smoke, however, has never been known to fail. It is not to be doubted, that, excepting the true plague, there has been an infection fully as pestilential and as mortal in some ships as in any other place whatever; yet it has never been heard, that any ship, after having been carefully smoked, did not immediately become healthy: and if afterwards they turned sickly, it was easy to trace that sickness from other infected ships, jails, and the like places.

There are three methods practised for purifying vessels after the men have been removed out of them. The first is by burning of tobacco. A quantity of tobacco is spread on several fires, made with such old pieces of rope as are called *junk*. These are dispersed into different places of the ship, and their heat and smoke afterwards closely confined below for a considerable time.—The second method is by charcoal fires strewed with brimstone. The heat and steam of these burning materials must also be long and close shut up: but although this fume, properly applied, has been found by experience to purify most effectually tainted apartments, ships, clothes, &c. yet there are some kinds of vermin which it will not destroy, particularly lice. The third method of purification is performed by the addition of arsenic to the materials of the second process, Febres. cess in the following manner. After carefully stopping up all the openings and every small crevice of the ship (as was also necessary in the preceding processes), a number of iron pots, properly secured, are to be placed in the *hold*, *orlope*, *gun-deck*, &c. Each of these is to contain a layer of charcoal at the bottom, then a layer of brimstone, and so alternately three or four layers of each, upon which the arsenic is to be sprinkled, and on the top of it some oakum dipped in tar is to be laid to serve as a match. The men, upon setting fire to the oakum, must speedily leave the place, shutting close the hatchway by which they came up.

From the known and experienced efficacy of these processes, it appears, that fire and smoke are powerful agents for annihilating infection; and it may be presumed, even the plague itself. This is in some measure agreeable to what we learn from the ancient records of physic. But the preposterous use, or rather abuse, of fire on such occasions, has caused its effects to be disregarded by some, and to be suspected of mischief by others. The modern practice of burning large fires in the open air, in the streets, and about the walls of towns infected with the plague or other contagion, is founded on principles groundless and erroneous; and has therefore been found by experience not only unsuccessful, but hurtful. But though this must be allowed, it does not thence by any means follow, that when once a house has been infected, and the patients removed from it, the doors and windows at the same time being shut, that such fires will then prove hurtful; or that, by this method of purification, all the seeds of contagion may not be effectually destroyed. Whenever, therefore, persons die of a spotted fever, a malignant sore throat, the small pox, or any distemper found to be communicable from the sick to the sound, the corpse ought quickly after death to be removed into another room; that in which the person died should be well aired, by having the windows opened, till a charcoal fire be kindled, with some rolls of sulphur upon it; after which, both doors and windows should be kept shut for a considerable time, not less than eight or ten hours, till the room be thoroughly smoked. In several ships, where there are the fairest opportunities of trying and judging things of this nature, the contagion of the small pox has been entirely stopped by wood-fires, sprinkled with brimstone, kept burning and closely confined in the infected place. In a word, a judicious and proper application of fire and smoke is a powerful agent for the destruction and utter extinction of the most malignant sources of disease; and they are besides great purifiers of all bad and tainted air.

Next to the smoke of wood for purifying a tainted air, that of gun-powder is to be esteemed the best; and it has this further good property, that it is entirely inoffensive to the lungs. The cascarilla bark, when burning, gives a most agreeable scent to the chamber of the sick; thus it is at least an elegant preservative, and may prevent bad smells from taking effect. The steam of camphorated vinegar, warmed, is still more powerful for this purpose. But, besides correcting the ill quality of the air, and purifying the chamber, another good effect is produced from such steams and smoke as are inoffensive to the lungs. As soon as the vapour becomes dense, the nurses and patients become desirous of the admission of fresh air by the doors or windows. Now it is certain, that the air in the chambers of the sick cannot be too often changed, provided the patient be well covered, and the curtains of his bed, if necessary, be drawn close. No argument is so forcible to obviate the danger of foul air in a room or ward (occasioned by the obstinacy of nurses and relations), as ordering it to be frequently fumigated or smoked: A practice more frequent in other countries than in this, but of great benefit to the sick.

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Lastly, with regard to the method of purifying goods, moveables, clothes, &c. which are supposed to harbour infection, it must be observed, that the usual custom of only unpacking and exposing such materials to the open air, is in many instances insufficient to destroy the latent seeds of disease. It is certain indeed, that in most cases the contagious particles are more readily and fatally communicated from the clothes of a sick person than from his body. The spreading abroad, therefore, of contaminated clothes to dry or to be aired, without a previous fumigation of them, may be of dangerous and fatal consequences. All such suspected substances should be first fumigated in a close place, and in the same manner as an infected chamber, after which they may be spread abroad and exposed to the air. In infectious diseases, especially fevers, the linen of the sick, or such clothes about them as will admit of being washed, ought never at first to be put in warm water, as it is dangerous to receive the steam that may hence arise. It is necessary to steep them first either in cold water or in cold soap-lees for several hours, that the filth may be washed off.

But although the destruction of contagion by smoke is unquestionably a very important practice, yet it cannot now be said, that it is the most powerful agent for this purpose. By the ingenious observations and experiments of M. Morveau in France, and of Dr Smyth Carmichael in England, it is now ascertained, that we possess still more powerful means of destroying contagions, either in the muriatic or nitrous acid gas. The former may easily be detached from common sea salt, and the latter from nitre, by means of the sulphuric acid. Rooms may, with the utmost safety and ease, be filled with these fumes, although the sick be not removed from them. But for disinfecting a room, ward, or ship, when empty, the most powerful article yet discovered is the oxygenated muriatic acid gas, detached from a mixture of manganese and sea salt, by means of the sulphuric acid.

We must now proceed to give an account of the method of cure, after these means of preventing the infection from being received into the body have either been neglected or proved ineffectual. Here it is of the utmost importance to take the disease in the very beginning, before it has time to corrupt the fluids to such a degree as to endanger life. In slight degrees of infection, a vomit properly administered, especially if succeeded by a blister, never fails to remove the disorder, and prevent the fever which would otherwise unavoidably follow. Of this Dr Lind gives the following instances. A lady afflicted with the bilious cholic, had intolerably fetid discharges of corrupted matters upwards and downwards. A gentlewoman, only in passing the room, was immediately seized with a retching and sickness, which continued 24 hours. The nurse who attended was suddenly seized

Fevers. zed with a giddiness and vomiting from the bad smell, which, as she expressed it, reached into her stomach. The vomiting became more severe at night, accompanied with a purging and frequent shiverings. By means of an emetic both evacuations were stopped: notwithstanding which, for some days afterwards, she continued to have frequent tremors, and a violent headach, with a low irregular pulse; and did not recover so soon as the patient.

Such slight degrees of infection have been often observed to be derived from patients of a gross habit of body when labouring under inflammatory distempers, and even other complaints. A man was sent to Haslar Hospital, supposed to have a fever. He was furiously delirious, with a quick full pulse. Notwithstanding plentiful evacuations, this delirium continued for two months with short intervals: when the case was found to be plainly maniacal. A nurse, upon raising this person up in her arms, perceived an intolerably bad smell, and was instantly seized with shiverings, sickness, and headach. Finding herself very ill, she took a vomit in six hours afterwards, and passed the night in profuse sweats by means of a sudorific draught. Next morning the violence of the headach was but little abated; upon every attempt to move, she complained of a burning heat and pain in her forehead, and became giddy. Her inclination to drink was frequent, and her pulse low and quick. A blister was immediately applied to the back; as soon as the blister took effect, the headach and thirst entirely left her, and the pulse was calm. Next day she arose and was well.

Many similar instances of infection have been observed from putting the dead into their coffins. In particular, one man, from performing that duty to his messmate, was so ill, even after the operation of the vomit, as to require a blister. In the course of one week two nurses were infected by a person in the smallpox. Both were seized in like manner with shiverings, sickness, and headach; the one upon receiving the patient's breath, the other upon making his bed. In one, a pain darted into her breast; in the other, into the breast and into the small of the back. The complaints of the former were speedily removed by a vomit, though she continued to have irregular returns of shiverings for three days afterwards. But in the latter, though the headach, sickness, and rigors, were greatly abated by the vomit, yet a constant heat and thirst, with a low pulse, and a violent pain in the breast, indicated the necessity of applying a blister to the affected parts, which next morning removed all her complaints.

A person is often immediately sensible of his having received infection from the first attack: they generally compare the first impression to an earthy disagreeable smell, reaching down, as they express it, into their stomach, as from a grave newly opened, but not quite so raw as the cadaverous stench; and the effects of it, shivering and sickness, are instantaneous. It is a smell difficult to describe; but it is well known to the nurses and attendants upon the sick, as it usually accompanies fevers of extreme malignity, and, with the peculiar discharges from the blistered parts, may be reckoned among the most constant symptoms of a bad fever. Some compare the smell to that of rotten straw. It often resembles the disagreeable smell of a person labouring under the confluent smallpox at their turn, though not so strong. One person, on receiving the infection, was sensible of something like an electric shook through his body. But many are not sensible of any effect from infection at first; and an infection from a fever will sometimes continue for many days, nay weeks, discovering itself chiefly by irregular shiverings, sometimes so severe as to oblige the patients to have recourse to their beds once or twice a-day; sometimes every other day. Among a number thus affected, it also appears, that such as are put into unseasoned chambers, or have sat down on the cold ground, lain in raw damp apartments, &c. are immediately seized with a sickness at stomach, sometimes with a dangerous purging, and often with fevers accompanied with bad symptoms, which others have entirely escaped.

Typhus. It now remains to consider the proper method of curing putrid fevers, on the supposition that the infection has been allowed to operate till the blood becomes radically tainted, and of consequence the nervous system affected to such a degree, that its power cannot be restored by any of the simple practices above mentioned. Here all authors agree, that a change of air, when it can be effected, is highly advantageous, and often contributes more towards the removing the disease than all the medicines that can be exhibited. The utility of this change will appear from what has been formerly said; and we shall only further mention one instance from Dr Lind, in which the effects of bad air appear to a degree almost incredible. "It is remarkable (says he), that, in the last war, the English ships which touched at Batavia suffered more by the malignant and fatal diseases of that climate, than they did in any other part of India, if we except a fatal scurvy which once raged in that fleet at sea. Soon after the capture of Manilla, the Falmouth, a ship of 50 guns, went to Batavia, where she remained from the latter end of July to the latter end of January; during which time she buried 100 soldiers of the 79th regiment, and 75 of the ship's company; not one person in the ship having escaped a fit of sickness, except her commander Captain Brereton. The Panther, a ship of 60 guns, was there in the years 1762 and 1764; and both times during the rainy season. In the former of these years, she buried 70 of her men; and 92 of them were very ill when she left the place. In the year 1764, during a short stay, 25 of her men died. The Medway, which was in company with her, lost also a great number of men. Nor was the sickness at that time confined to the ships: the whole city afforded a scene of disease and death: streets crowded with funerals, bells tolling from morning to night, and horses jaded with dragging the dead in herses to their graves. At that time a slight cut of the skin, the least scratch of a nail, or the most inconsiderable wound, turned quickly to a spreading putrid ulcer, which in 24 hours consumed the flesh even to the bone. This fact is so extraordinary, that upon a single testimony, credit would hardly be given to it; yet on board the Medway and Panther they had the most fatal experience of it, and suffered much from it."

But where a change of air is impracticable or ineffectual, and where the fever has already made some progress, Sir John Pringle generally took away some blood if the pulse was full. When the symptoms run high,

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high, a plentiful evacuation of that kind seemed indicated; yet it was observed, that large bleedings generally did harm, by sinking the pulse, and affecting the head. Nor was a moderate bleeding to be repeated without caution; even those whose blood was sizy, unless their lungs were inflamed, were the worse for a second bleeding. If the head only suffered, it was much safer to use leeches than to open a vein in the arm; but in the delirium with a sunk pulse, even leeches were hurtful. Many recovered without letting blood, but few who lost much of it.

Emetics also must be used with caution; for though they may be of service by way of prevention, yet in the advanced state of the disease, when the patient has all along complained of a sickness at stomach, they are evidently unsafe. Here the antiseptic quality of fixed air is of much use, and the neutral draughts given in the act of effervescence are generally attended with happy effects. Nay, clysters of fixed air itself have been found serviceable. Even in very bad stages of the distemper, where a putrid and colliquative looseness has taken place, clysters of fixed air have been known to alleviate the symptoms. We must not, however, put too much confidence in medicines of this kind. Mild tonic cordials, especially wine and cinchona, are the only resources in these disorders. Concerning the former, Sir John Pringle observes, in the low state of these fevers, and in great sinkings, which either come after unseasonable bleedings or long want of nourishment, it was a most grateful and efficacious cordial, to which nothing was comparable. The common men had an allowance, from a quarter to half a pint in a day, of a strong kind made into whey, or added to the panada which was their ordinary food. But to others out of the hospital, he usually prescribed Rhenish or a small French wine, whereof some consumed near a quart per day, and part of that undiluted. Nay, so great was the virtue of wine in this stage of the fever, that several were known to recover from the lowest condition, when, refusing the bark on account of its taste, they took nothing but a little panada with wine, and a volatile diaphoretic mixture, every two or three hours by turns. Perhaps there is no rule more necessary in this state, than not to let the patient when low remain long without taking something cordial and nourishing; as many have been observed past recovery, by being suffered to pass a whole night without any support about the time of the crisis. In the advanced state of this fever the sick are remarkably low; and therefore Hoffman advises in such cases, that they should be constantly kept in bed, and not permitted even to sit up in it. In the last stage of this fever, as well as in that of the sea-scurvy, it would seem that the force of the heart was too small to convey the blood to the brain, except when the body is in a horizontal posture.

But, however necessary wine and cinchona may be in the low stage of this fever, we must remember, that these remedies are to be administered only as antiseptics and supporters of the *vis vitæ*, without aiming at thoroughly raising the pulse or relieving the head, or at forcing a sweat by them, before nature points that way, and which Sir John Pringle seldom observed before the 14th day.

In the low state of the hospital fever, a stupor was a constant attendant, which was very apt, in the evening, to change to a slight delirium. If this was all, nothing was done. But if the delirium increased upon using wine, if the eyes looked wild, or the voice became quick, there was reason to apprehend a phrenitis; and accordingly it was observed, that at such times all internal heating medicines aggravated the symptoms; and in these cases, blisters were of the greatest service. Fomentations of vinegar and warm water for the feet, Sir John Pringle is of opinion, would answer better than either sinapisms or blisters, provided they were long enough and often enough applied. In the inflammatory fevers, he has known these fomentations have little effect for the first hour, and yet succeed afterwards. For internal medicine, cinchona was omitted for some time, but the patient was continued with an acidulated drink, viz. barley-water and vinegar; and treated also with camphire, *pulvis contrayervæ compositus*, and nitre, as was usual in the beginning of the fever. If the delirium was of the low kind, a decoction of cinchona and wine were the only remedies; for in no instance was the delirium perfectly removed till the time of the crisis. It must also be observed, that a delirium may arise in putrid fevers from two opposite errors; one from large and repeated bleedings, and the other from wine and cordial medicines being taken too early. It appears, therefore, how nice the principles are that regard the cure; as neither a hot nor a cool regimen will answer with every patient, or in every state of the disease.

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If a diarrhœa came on in the decline of the fever, it was moderated, but not suppressed, by adding an opiate to the usual medicines. For though the looseness may be considered as critical; yet as the sick were too low to bear evacuations, there was a necessity for restraining it in some measure; and it has often been observed, that when it has been treated in this manner, about the usual time of the crisis, the patient has fallen into a gentle sweat, which has carried off the disease. In the worst cases of this fever, and especially when it coincides with the dysentery, the stools are frequently bloody; in which dangerous state, if any thing could be done, it was attempted by medicines of the same kind. In proportion to the putrid nature of the stools, opiates and astringents were used with the greater caution.

If the disease terminate in a suppuration upon one of the parotid glands, the abscess was opened without waiting for a fluctuation, which might never happen; the pus being often here so viscid, that after it was ripe the part felt nearly as hard as if the suppuration had not begun.

Almost every patient, after the fever, complained of want of rest, frequently of a vertigo or confusion of the head, of a continuation of the deafness, or of other symptoms commonly called *nervous*. An opiate was then given at night; and in the day some strengthening medicines, such as cinchona and the sulphuric acid. In these cases, the bark was found not only to be the best strengthener, but the surest preservative against a return of the disease. For this last intention the convalescent was ordered about three drams a-day for six or seven days together; and afterwards, if he remained longer in the hospital, some smaller quantity daily. But if there was any appearance of a hectic

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tic fever from an inward abscess, the case was treated accordingly. Upon comparing some of the remaining symptoms of those who recovered, with the condition of the brain in those who died and were opened, Sir John Pringle was induced to think, that some part even of that substance might suppurate, and yet the person recover.

Sometimes the patient falls into an irregular intermittent; which, if not of a hectic nature from an internal abscess, may proceed from neglecting to clear the *primæ viæ*. For it is easy to conceive, that after a long fever of such a putrid nature, often attended with languor of the bowels, the fæces may be so much accumulated, and so corrupted, as to occasion new disorders. In such cases, after proper evacuation by a purge, cinchona was almost an infallible remedy.

The Yellow Fever.

Typhus cum flavedine cutis.

Typhus icteroides, *Sauv.* sp. 7.

7 *Febris flava Indiæ Occidentalis*, *Warren.* Malignant Fever of Barbadoes, *Hillary's* Diseases of Barbadoes. *Lining* on the Yellow Fever of South Carolina, Edin. Phys. and Liter. Essays, vol. ii. *M'Kittrick* de Febre Flavâ Indiæ Occidentalis, Edin. 1766.

Description. This is one of the most fatal diseases to which the inhabitants of warm climates are subject, and is the same with that called, from one of its worst symptoms, the *black vomit*, which is so terribly destructive in some of the warm parts of America, particularly at Carthagena; and which of late has proved so fatal in Philadelphia, New York, and the British West India islands, as described by Drs Rush, Chisholm, Clerk, and other late writers. This, though by some considered as a new disease, is evidently from the same contagion which has produced fatal fevers on many former occasions.

The yellow or putrid bilious fever has been in particular minutely described by Dr Hillary. It most commonly seizes the patient at first with a faintness, then with a sickness at stomach, accompanied in general with a giddiness of the head; and soon after with a slight chilness and horror, very rarely with a rigor. These symptoms are soon followed by a violent heat and high fever, attended with acute darting pains in the head and back. A flushing in the face, with an inflamed redness and a burning heat in the eyes, great anxiety and oppression about the præcordia, are the pathognomonic signs of the distemper, especially when attended with sickness at stomach, violent retchings, and bilious yellow vomitings, with frequent sighing. The pulse is now generally very quick, high, soft, and sometimes throbbing, but never hard: in some it is very quick, soft, low, and oppressed; the respiration quick, full, and sometimes difficult; the skin very hot, and sometimes dry, though more frequently moist. Blood taken from the patient, even at the very beginning of the disease, is often of an exceeding florid red colour, without the least appearance of size; and the crassamentum, when it has stood till it is cold, will scarce cohere, but fluctuates; the serum is often yellow.

Most of the above-mentioned symptoms continually increase, and are much aggravated: the retching and vomiting become almost incessant; the anxiety great, and sighing frequent; great restlessness; continual tossing; no ease in any posture; little sleep, and that disturbed and uneasy, and without any refreshment to the sick. When they are fainting, they turn yellow about the face and neck, instead of turning pale; and as the fainting goes off, they recover their natural colour. These symptoms generally continue till the third day, though sometimes not longer than the first or second; in others to the end of the fourth: the first shows the greater dissolution of the blood, and the greater malignity of the disease; the last, the contrary; which the improper manner of treating the disease sometimes hastens and increases, or the proper method retards. This may be called the first stadium of the disease, and generally ends on the third day.

Blood taken from the sick on the second or third day, is much more dissolved, the serum more yellow, and the crassamentum florid, loose, scarcely cohering, but undulates like sizy water when shaken, and sometimes has dark blackish spots on its surface, showing a strong gangrenescent diathesis.

About the third day, the pulse, which was quick and full before, now generally sinks greatly, and becomes very low: though sometimes it remains very quick, yet in others it is not much quicker than when the patient was in health, but is always low; the vomiting becomes almost incessant if not so before, and the matter thrown up is black; the patient then becomes comatose, with interrupted delirium. The thirst in some is very great, in others but little; the pulse still low and quick, attended with cold clammy sweats, and sometimes with deliquium. The eyes, which were inflamed and red before, and began to be of a more duskish colour, now turn yellow; and this yellowness also soon after appears round the mouth, eyes, temples, and neck, and in a short time diffuses itself all over the body. But this yellowness is so far from being always an encouraging prognostic, as some would have it, that it most commonly proves a mortal symptom. Sometimes indeed, though seldom, this suffusion of bile upon the surface has proved critical; but then it did not come on till the eighth or ninth day, nor appear till the coma and all the other bad symptoms began to abate; and then in proportion as the yellowness increases, all the bad symptoms decrease. But the case is most commonly quite the reverse; especially when the yellowness comes soon on: and then it ushers in the most fatal symptoms of the disease, viz. a deep coma, a low, vermicular, and intermitting pulse, great hæmorrhages from various parts of the body, a delirium with laborious and interrupted respiration, great anxiety, deep sighing, restlessness, a subsultus tendinum, coldness of the extreme parts first, and then all over the body, a faltering of the speech, tremors, and convulsions, which are soon after followed by death. So that from the first appearance of the yellowness we may say the patient is in the last stage of the disease, whether it terminates in death or recovery.

It has been observed, that, in some strong sanguine constitutions, when the patients have not been bled to a sufficient quantity in the beginning of the disease, the pulse has continued full, strong, and rapid, but never hard; the face flushed, eyes inflamed; the tongue dry, with great thirst and heat, till the second or last stage of the fever is come on, when the pulse has

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In the latter stage of this fever, the blood is so attenuated and dissolved, that we frequently see it flowing not only out of the nose and mouth, but from the eyes, and even through the pores of the skin; great quantities also of black, half-baked, or half-mortified blood, are frequently voided both by vomiting and by stool, with great quantities of yellow and blackish putrid bile by the same passages; and the urine, which was before of a high ictcritious colour, is now almost black, and is frequently mixed with a considerable quantity of half-dissolved blood. The pulse, which was much sunk before, now becomes very low, unequal, and intermitting; the breathing difficult and laborious; and the anxiety inexpressible; an oppression with a burning heat about the præcordia comes on, though the extremities are cold, and often covered with cold clammy sweats; a constant delirium follows; and then a total loss of the outward senses as well as the judgment, with livid spots in many parts of the body, especially about the præcordia; and sometimes gangrenes in other parts of the body, which are very soon succeeded by death.

In a short time after death, the body appears much more full of livid, large, mortified spots, particularly about the præcordia and hypochondres, especially the right; which parts seem, even from the first seizure, to be the principal seat of this terrible disease; and, upon opening the bodies of those who die of it, we generally find the gall-bladder and biliary ducts turgid, and filled with a putrid blackish bile; and the liver, stomach, and adjoining parts, full of livid or blackish mortified spots; and the whole corpse soon putrefies after death, and can be kept but a few hours above ground.

Dr Lind is of opinion, that the remarkable dissolution of the blood, the violent hæmorrhages, black vomit, and the other symptoms which characterize the yellow fever, are only accidental appearances in the common fever of the West Indies; that they are to be esteemed merely as adventitious, in the same manner as purple spots and bloody urine are in the smallpox, or as an hiccough in the dysentery: like these they only appear when the disease is attended with a high degree of malignity, and therefore always indicate great danger. This opinion, he thinks, is confirmed by an observation of Dr Wind's, that in 1750 the crew of a Dutch ship of war were distressed by the yellow fever, accompanied with the black vomit; but when the ship left the harbour, and changed the noxious land air for one more healthy, the fever continued, but was not accompanied with the black vomit.

Diseases similar to this fever, Dr Lind informs us, may arise in any part of the world where the air is intensely hot and unwholesome; and therefore he treats as chimerical the notion of its being imported from one part of the world to another. An example of this happened at Cadiz in Spain, in the months of September and October 1764, when excessive heat, and want of rain for some months, gave rise to violent, epidemic, bilious disorders, resembling those of the West Indies, of which 100 persons often died in a day. At this time the winds blew principally from the south, and after sunset there fell an unusual and very heavy dew. But his opinion on this subject is liable to strong objections. And however the disease may originate, yet the late introduction of it from Spain into the fortress of Gibraltar, from which, by proper attention, it had been excluded in former epidemics, demonstrates the contagious nature of this fever beyond all possibility of doubt.

It has been a matter of much dispute, whether the yellow fever is of an infectious nature or not. Some time ago it became an object of consideration before the Right Hon. the Lords Commissioners of Trade and Plantations, where it was urged, among other reasons for not removing the seat of government and justice in the island of Jamaica, from Spanish Town to Kingston, that there was danger from Greenwich hospital, situated near Kingston, of an infection from the yellow fever being frequently communicated to that town. On this affair a physician was consulted, who had long practised in that island, and who gave it as his opinion, that from the yellow fever in that island there was no infection. This was the opinion not only of that gentleman, but of many others who had an opportunity of being well acquainted with this fever in Jamaica. But this opinion probably only arose from these practitioners having confounded the ordinary remittent fever of the West Indies, which is often accompanied with bilious symptoms, and is from thence often denominated the yellow fever, with the typhus icteroides, a disease essentially different from the bilious remittent which often prevails both in the West and East Indies. Dr Lind gives a remarkable instance of its being of an infectious nature.—A gentleman dying at Barbadoes of a yellow fever, his wearing apparel and linen, packed up in a chest, were sent to his friends at Philadelphia; where, upon opening the chest, the family was taken ill; and the clothes being unluckily hung abroad to be aired, they presently diffused the contagion of the yellow fever over the whole town, by which 200 persons died.

In the description of the same fever by Dr Lining, as it appeared in South Carolina, there are several particulars considerably different from that by Dr Hillary. According to the former, people complained for a day or two before the attack, of a headach, pain in the loins and extremities, especially in the knees and calves of the legs, loss of appetite, debility, and a spontaneous lassitude. Some, however, were seized suddenly, without any such previous symptoms. After a chilliness and horror, with which this disease generally invades, a fever succeeded. The pulse was very frequent, till near the termination of the fever, and was generally full,

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full, hard, and consequently strong: in some, it was small and hard; in others, soft and small; but in all those cases, it frequently varied in its fulness and hardness. Towards the termination of the fever, the pulse became smaller, harder, and less frequent. In some there was a remarkable throbbing in the carotids and in the hypochondria; in the latter of which it was sometimes so great, that it caused a constant tremulous motion of the abdomen. The heat generally did not exceed 102 degrees of Fahrenheit's thermometer; in some it was less; it varied frequently, and was commonly nearly equal in all parts, the heat about the præcordia being seldom more intense than in the extremities when these were kept covered. On the first day of the disease, some had frequent returns of a sense of chilliness, though there was not any abatement of the heat. In a few, there happened so great a remission of the heat for some hours, when at the same time the pulse was soft and less frequent, and the skin so moist, that one from these circumstances might reasonably have hoped that the fever would only prove a remittent or intermittent. About the end of the second day, the heat began to abate. The skin was sometimes (though rarely) dry; but oftener, and indeed generally, it was moist, and disposed to sweat. On the first day, the sweating was commonly profuse and general; on the second day, it was more moderate: but on both these, there happened frequent and short remissions of the sweatings; at which times the febrile heat increased, and the patient became more uneasy. On the third day, the disposition to sweat was so much abated, that the skin was generally dry; only the forehead and backs of the hands continued moist. The respiration was by no means frequent or difficult; but was soon accelerated by motion, or the fatigue of drinking a cup of any liquid. The tongue was moist, rough, and white, even to its tip and edges. On the second day, its middle in some was brown. On the third day, the whiteness and roughness of the tongue began to abate. The thirst in very few was great. A nausea, vomiting, or frequent retchings to vomit, especially after the exhibition of either medicines or food, came on generally the third day, as the fever began to lessen; or rather as the fulness of the pulse, heat, and disposition to sweat, began to abate. Some indeed, but very few, on the first day, had a vomiting, either bilious or phlegmatic. Very few complained of anxiety or oppression about the præcordia or hypochondria, nor was there any tension or hardness about the latter. On the first day they generally dozed much, but were afterwards very watchful. Restlessness and almost continual jactations came on the second day. A great despondency attended the sick, and the strength was much prostrated from the first attack. The pain in the head, loins, &c. of which they had complained before the attack, was much increased, and in some the pain in the forehead was very acute and darting; but those pains went generally off the second day. The face was flushed; and the eyes were hot, inflamed, and unable to bear much light. On the first day, many of them at times were a little delirious, but afterwards not until the recess of the fever. The blood drawn by venesection had not any inflammatory crust; in warm weather, it was florid like arterial blood, and continued in one soft homogeneous-like mass, without any separation of the serum after it was cold. When there was any separation, the crassamentum was of a very lax texture. The stools, after the first day, were fetid, inclined to a black colour, and were very rarely bilious, soft, or liquid, excepting when forced by art; for an obstinate costiveness attended the febrile state. The urine was discharged in a large quantity, was pale, sometimes limpid, and rarely of a higher than a straw colour, except when the weather was very warm, and then it was more saturated, of a deep colour, and discharged in smaller quantities. It had a large cloud, except when it was very pale or limpid; but more generally it had a copious white sediment, even on the first day of the fever. On the second day, the urine continued to be discharged very copiously; in some it was then turbid, and deposited a more copious sediment than on the first day; this sediment was sometimes of a brownish colour; in which case it was generally followed by bloody urine, either about the end of the second or beginning of the third day.—The colour and quantity of the urine, discharged in equal times, were remarkably variable, being now limpid, then of a deeper colour; now discharged in a larger, then in a smaller quantity; which could not be ascribed to any change made either in the quantity or quality of the drink.

The fever accompanied with those symptoms terminated on the third day, or generally in less than 72 hours from the first attack, not by any assimilation or coction and excretion of the morbid matter: for if by the latter, there would have been some critical discharge by sweat, urine, stool, or otherwise, none of which happened; and if by the former, nothing then would have remained but great debility. This fever, however, did not terminate in either of these salutary ways, excepting in some, who were happy enough to have the disease conquered in the beginning by proper evacuations, and by keeping up a plentiful sweat, till the total solution of the fever, by proper mild diaphoretics and diluents. But in those who had not that good fortune, however tranquil things might appear, yet the face of affairs was quickly changed: for this period was soon succeeded by the second *stadium*; a state, though without any fever, much more terrible than the first: the symptoms in which were the following. The pulse, immediately after the recess of the fever, was very little more frequent than in health, but hard and small. However, though it continued small, it became, soon afterwards, slower and very soft; and this softness of the pulse remained as long as the pulse could be felt. In many, in this stage of the disease, the pulse gradually subsided, until it became scarce perceptible; and this, notwithstanding all the means used to support and fill it; and when this was the case, the icteritious-like suffusion, the vomiting delirium, restlessness, &c. increased to a great degree. In some, the pulse, after being exceedingly small and scarce perceptible, recovered considerably its fulness; but that favourable appearance was generally of but short continuance. The heat did not exceed the natural animal heat; and when the pulse subsided, the skin became cold, and the face, breast, and extremities acquired somewhat of a livid colour. The skin was dry when the weather was cold, but was moist and clammy when the weather was hot, the respiration was

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was natural, or rather slow. The tongue was moist, and much cleaner than in the former stage; its tip and edges, as also the gums and lips, were of a more florid red colour than usual. Very few complained of thirst, though they had a great desire for cold liquors. The vomiting or retching to vomit increased, and in some was so constant that neither medicines nor aliment of any kind were retained. Some vomited blood; others only what was last exhibited mixed with phlegm; and others again had what is called the black vomit. The retching to vomit continued a longer or shorter time according to the state of the pulse; for as that became fuller, and the heat greater, the retching to vomit abated, and *è contra*. The inquietude was very obstinate; and when they dozed their slumbers were but short and unrefreshing. There were some who were drowsy; but these always awaked, after the shortest slumbers, with a great dejection of spirits and strength. The jactations or restlessness were surprising: it was frequently scarce possible to keep the patients in bed; though at the same time, they did not complain of any anxiety or uneasiness; but if asked how they did? the reply was, *Very well*. The debility was so great, that, if the patient was raised erect in the bed, or, in some, if the head was only raised from the pillow, while a cup of drink was given, the pulse sunk immediately, and became sometimes so small, that it could scarce be felt; at this time, they became cold, as in a horripilatio, but without the anserine-like skin: their lips and skin, especially about the neck, face, and extremities, together with their nails, acquired a livid colour. The delirium returned and increased; it was generally constant in those whose pulse was small and subsiding. The inflammation of the tunica conjunctiva or white of the eyes increased much, but without pain. A yellowness in the white of the eyes, if it did not appear before in the febrile state, became now very observable, and that icteritious tinct was soon diffused over the whole surface of the body, and was continually acquiring a deeper saffron-like colour. In some, indeed, no yellowness was observable, excepting in the white of the eyes, until a little before death, when it increased very quickly, especially about the breast and neck. There were many small specks, not raised above the skin, which appeared very thick in the breast and neck, but less so in the extremities, and were of a scarlet, purple, or livid colour. In women the menstrua flowed, and sometimes excessively, though not at their regular period.

There was such a putrid dissolution of the blood in this stadium of the disease, that there were hæmorrhages from the nose, mouth, ears, eyes, and from the parts which were blistered with cantharides. Nay, in the years 1739 and 1745, there were one or two instances of an hæmorrhage from the skin, without any apparent puncture or loss of any part of the scarf-skin.

An obstinate costivenes continued in some; in others, the stools were frequent and loose: in some they were black, liquid, large, and greatly fatiguing; in others, when the stools were moderate, even though they were black, they gave great relief; in others, again, the stools nearly resembled tar in smoothness, tenacity, colour, and consistence.

The urine was discharged in a large quantity, in proportion to the drink retained by the patient: it was pale if the patient was not yellow; but if yellow, then it was of a deep saffron-colour: in either case, it had a sediment, or at least a large cloud, which remained at the bottom of the glass; in some, it was very turbid; in others it was bloody: and the quantity of blood discharged with the urine bore always some proportion to the state of the pulse; when that became fuller, the quantity of blood in the urine was diminished; when the pulse subsided, the bloody urine increased, and even returned after it had ceased some days, soon after the pulse became smaller. This stage of the disease continued sometimes seven or eight days before the patient died.

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When this stadium of the disease terminated in health, it was by a recess or abatement of the vomiting, hæmorrhages, delirium, inquietude, jactations, and icteritious-like suffusion of the skin and white of the eyes; while, at the same time, the pulse became fuller, and the patient gained strength, but very slowly. But when it terminated in death, those symptoms not only continued, but sooner or later increased in violence, and were succeeded with the following, which may be termed the third *stadium* of the disease, which quickly ended in death. The pulse, though soft, became exceedingly small and unequal; the extremities grew cold, clammy, and livid; the face and lips, in some, were flushed; in others, they were of a livid colour; the livid specks increased so fast, that in some the whole breast and neck appeared livid; the heart palpitated strongly; the heat about the præcordia increased much; the respiration became difficult, with frequent sighing; the patient now became anxious, and extremely restless; the sweat flowed from the face, neck, and breast; blood flowed from the mouth, or nose, or ears, and in some from all those parts at once; the deglutition became difficult; the hiccoughs and subsultus tendinum came on, and were frequent; the patients trifled with their fingers, and picked the naps of the bedclothes; they grew comatose, or were constantly delirious. In this terrible state, some continued eight, ten or twelve hours before they died, even after they had been so long speechless, and without any perceptible pulsation of the arteries at the wrists; whereas, in all other acute diseases, after the pulse in the wrists ceases, death follows almost immediately. When the disease was very acute, violent convulsions seized the unhappy patient, and quickly brought this stadium to its fatal end. After death, the livid blotches increased fast, especially about the face, breast, and neck, and the putrefaction began very early, or rather increased very quickly.

Such was the progress of this terrible disease through its several stadia. But in hot weather, and when the symptoms in the first stage were very violent, it passed through those stages with such precipitation that there was but little opportunity of distinguishing its different stadia, the whole tragedy having been finished in less than 48 hours. It was remarkable, that, 1. The infection was increased by warm and lessened by cold weather. 2. The symptoms in the several stadia were more or less violent, according to the heat or coolness of the weather. In hot days, the symptoms were not only more violent, but in those who seemed in moderate weather to be on the recovery, or at least in no danger, the symptoms were all so greatly heightened, when

 when the weather grew considerably warmer, as frequently to become fatal. In cool days, the symptoms were not only milder, but many who were apparently in great danger in hot days were saved from the very jaws of death by the weather becoming happily cooler. 3. The disease was generally more fatal to those who lay in small chambers not conveniently situated for the admission of fresh air, to those of an athletic and full habit, to strangers who were natives of a cold climate, to those who had the greatest dread of it, and to those who before the attack of the disease had overheated themselves by exercise in the sun, or by excessive drinking of strong liquors; either of which indeed seemed to render the body more susceptible of the infection. Lastly, The disease proved most certainly fatal to valetudinarians, or to those who had been weakened by any previous disease.

Causes of, and persons subject to, this disease. The yellow fever attacks principally Europeans, especially those who have but lately arrived in the hot climates. Negroes are entirely exempt from it, though the mulattoes and tawnies are as liable to be seized with it as the whites themselves. The cause of the disease seems to be a particular kind of contagion; but Dr Lind seems to be of opinion, that the immediate cause of the symptoms is a disposition in the glutinous part of the blood to separate from the others, and to become putrescent. In some persons who have been bled in the yellow fever, the blood has been observed very viscid; the crassamentum covered with a yellow gluten half an inch in thickness, and impenetrable to the finger unless cut by the nail; the serum being at the same time of the consistence of a thin syrup, and of a deep yellow tinct. This serum tasted bitter, and resembled a composition of soot. The appearances on dissection, with his conclusions from them, we shall give in his own words: "In a man who died on the eleventh day of a yellow fever, whose body emitted no bad smell 36 hours after death, and was still yellow, I found all the bowels of the abdomen sound; the liver and spleen were remarkably so; as also the stomach and intestines. There was no suffusion of the bile either in the intestines or stomach. The gall-bladder, of the natural size, contained the usual quantity of bile, somewhat thicker than common, and grumous (B).

"Upon examining further, this disease was found to have lain wholly on the left side, where, within the breast, was found near a quart of yellowish water, in which were many large flakes of yellowish gluten, appearing, by comparison, precisely the same with the thick pellicle which had covered the blood taken from his arm. These flakes bore in several places a resemblance to a membranous substance beginning to be converted into a purulent jelly. The pleura, both on its inside and outside, as also its continuation, the investing membrane of the lungs, were covered with cakes of this gluten, hanging in some places loosely, in others adhering more strongly: and all in different states of yellow or purulent corruption. The right cavity of the breast, and all the other parts of his body, were found entirely free from disease.

"His complaints had been chiefly in his breast; and a small quantity of blood taken from him two days before his death, was covered with an impenetrable, yellow, thick gluten; the red portion below it being quite loose.

"In those fevers, I have also seen (says Dr Lind) the disease entirely confined to the heart and pericardium. In one who died on the tenth day of the fever, without having been yellow, a quantity of pus and purulent crusts was found mixed with the water of the pericardium. The heart in different places was excoriated; and, together with the inside of the pericardium, was lined with a thick membranous cake, similar to that already mentioned on the lungs and pleura. In some places this cake had a purulent, in others a gelatinous appearance, exactly resembling the coagulum of the blood. His complaints had been, a great oppression on the breast, and an extreme difficulty of breathing. In a third person, who died on the thirteenth day of the fever, above two quarts of pus and purulent jelly were found in the cavity of the belly. The source of such an extraordinary quantity of matter was not from any preceding inflammation, nor any imposthume, that we could discover; but from innumerable ulcerations on the surface of the intestines, omentum, mesentery, and peritoneum. Neither did those ulcerations (or excoriations, as they rather appeared in several places) seem to be the primary fountains of the matter, but to have been occasioned by its acrimony.

"This purulent appearance seems to arise merely from an extravasation of one of the component parts of the blood, the gluten or fibrine as it is now called. Blood taken from persons in a fever, and frequently even from persons in perfect health, after standing in a clean vessel for a short time, commonly separates into three distinct portions; viz. the serum, or water of the blood, the red concreted mass, and a viscid pellicle termed the *size*, which spreads itself on the top of the red concretion. Some time ago, when making experiments with the blood taken from persons in the scurvy, I was surprised to find it often covered with that sizy crust. This induced me to extend my experiments to large quantities of blood from different subjects, which I had opportunities of inspecting at once in so large an hospital. For this purpose I one morning ordered ten patients in the scurvy to be bled, taking two ounces from each. A larger quantity was taken, for its inspection, from two men in health. That day I had occasion to prescribe bleeding to a woman in labour, two hours before her delivery; to a girl of sixteen years of age afflicted with a lunacy proceeding from the chlorosis; to three patients in the rheumatism; and to a person labouring under an obstruction of the liver.

"From a nice comparison, and an examination of the blood in these cases, I found in general, that the more

(B) In others who died in this yellow state, the bile in the gall-bladder was found of a thick ropy consistence like pitch, but the liver never appeared in the least affected. Dr Lind at first in several bodies opened the head only; but afterwards judged that all the cavities ought to be inspected.

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more size there was on the top, and the thicker and more viscid this white pellicle showed itself, the concretion below it was of a more loose coherence. This was not so observable when only some slight white streaks appeared on the top. But when much size had separated itself, the red mass became very soft at the bottom of the vessel, and less compact in its different parts, in proportion to their distance from the surface, towards which this whitish portion had ascended.

"From this and from other experiments it appears, that this crust or pellicle is the natural gluten, which becomes strongly disposed, in certain circumstances and diseases, to separate itself. And wheras the serum and red concretion are easily incorporated together, it will be found, that this glue, after its separation, becomes immiscible with either. We have, by gentle drying, converted it into a perfectly tough elastic membrane; and, by the means of a small portion of the red mass being left adhering to it, into a substance resembling muscular flesh; and it is capable of undergoing various changes into corruption, in the same manner as either of these.

"Now, I can see no reason why this gluten, in its morbid state, may not separate itself from the circulating blood, and be deposited in the cavities of the body, as readily as the serum does in dropsies; the former having always a less disposition than the latter to incorporate with the mass.

"In dissecting persons who died of fevers in London and Minorca, and where no infection was suspected, appearances similar to these have also fallen under the inspection of those accurate anatomists Drs Hunter and Cleghorn. Hence it may be presumed very difficult to distinguish fevers that are produced by infection, from some others. I cannot, however, be induced to think, as those gentlemen seem to do, that these preternatural substances which were found in the cavities of the body are the consequence, but rather that they are the cause, of the inflammation and excoriations. I believe these substances to be at first diseased extravasated gluten, and conjecture their different states greatly to depend upon the different times at which they were deposited.

"I have remarked, in a variety of dead bodies, three different kinds of extravasation; these occurred in such as had died of the scurvy, of consumption, and of fevers. In the former of those diseases, red coagulated blood is found extravasated in almost all parts of the body, not only into the tela cellulosa, but into the bellies of the muscles, particularly of the legs and thighs, which often become quite stuffed and even distorted with large grumous masses. The intestines and mesentery are often spotted also with extravasated blood; and I have seen large ecchymoses on the stomach. Those appearances at first sight resembled so many distinct mortifications; and by this appearance some anatomists have been deceived; but, upon a nice examination, the texture of the parts is found to be sound and firm. There is likewise, in that disease, sometimes an extravasation of water, chiefly collected in the tela cellulosa.

"But as, in the limbs of scorbutic persons, it is extremely difficult to make a good dissection by reason of such quantities of extravasated blood that everywhere obstruct the operator; so, on the contrary, the lower extremities of those who have died consumptive, with swelled legs, are, of all subjects, in the best state to afford a satisfactory view of the muscles. The water enclosed in their legs having insinuated itself, by passing the tela cellulosa, into the spaces between the muscles, the muscles are easily separated from each other; and their several origins and insertions may be distinctly traced by means of their having been cleansed and washed by the water in the investing cellular membrane. Thus there are extravasations of three sorts; viz. First, The grumous mass in the scurvy; and this I have often remarked where no serum was observed. Secondly, The serum alone in anasarcous swellings. The third and last is what was taken notice of in those who died of fevers, being the gluten of the blood, accompanied for the most part with some serum; both of them altogether confined to the large cavities of the body.

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"I conjecture, that in those fevers there is always an ulcerous or purulent disposition in the blood: and that the gluten is greatly diseased. I have frequently seen it have a true purulent appearance soon after it was drawn off, when the patient seemed not very ill.

"And I further conjecture, that the mischief often lies within the breast; as also that the great benefit derived from the very early application of blisters, in a great measure flows from so many ulcerations and vents being timely provided for the free discharge of those purulent and tainted particles from the body.

"If an infection depends, as many have imagined, on the admission of certain foreign particles into the blood, this gluten seems to be primarily affected by it; and a discharge of this, by washing those particles out of the body, tends in a great measure to remove that disease.

"It is an observation of the best practical writers, that issues and setons are most excellent preservatives against receiving an infection, even that of the plague itself. And indeed a suppuration and plentiful discharge from a proper ulcer, whether produced by nature or by art, seems to open a channel the best appropriated for an exit out of the body to some of the most malignant poisons. Thus the most favourable crisis in the plague, and in most pestilential fevers, happens when nature excites tumors kindly suppurating in the groin or armpits, by whose beneficial and plentiful discharge the deadly poison is expelled from the constitution.

"I have observed it to be amongst the most certain characteristics of the worst fevers, that the blisters either do not rise and fill, or discharge such yellow, greenish, fetid, and highly offensive stuff, that even experienced nurses could give a pretty certain conjecture from the blisters of the different degrees of malignity in the fever. We have more than once endeavoured to conceal the bad state of some patients in the hospital; but a discovery was always made of their condition in the washhouse, from the linen sent there stained with the discharges from the blistered parts. And indeed a careful inspection of the state and discharge from the blisters, together with their effects, furnishes us, in those diseases, with some of the most certain diagnostics of their nature, and prognostics of their event."

Prognosis. This distemper, where it attacks with violence,

violence, is generally fatal; the prognosis therefore must be commonly unfavourable, and always uncertain; neither can any thing more be said on this subject, than that an abatement of the symptoms already enumerated affords a favourable prognostic, and an increase of them the contrary.

Cure. The cure of this terrible disease, according to Dr Hilary, is very easy and simple. His indications are, 1. To moderate the too great and rapid motion of the fluids, and abate the too great heat and violence of the fever in the two first days of the disease, as much and as safely as we can. 2. To evacuate and carry out of the body as much of the putrid bile and other humours, and as expeditiously and safely as possible. 3. To put a stop to the putrescent disposition of the fluids, and to prevent the gangrenes from coming on, by suitable antiseptics.

The first indication is answered by bleeding, which, in the first stage of this fever, is sometimes absolutely necessary in some degree: the quantity to be taken away must be determined by the age and strength of the patients, the degree of plethora, fulness of the pulse, &c. When called at the beginning, he orders 12, 14, 16, 18, or 20 ounces of blood to be taken away on the first or second day; and if the patient's pulse rise after the first bleeding, or if the fever still continue high and the pulse full, he repeats the bleeding once on the days above mentioned. But bleeding a third time is seldom or never required; neither is bleeding on the third day almost ever necessary; and when it is performed on that day, it ought to be done with the greatest caution and judgment: neither should a vein be opened after the third day in this fever, unless some very extraordinary symptoms and circumstances require it; which seldom or never happen. On that day, indeed, the pulse generally sinks, and the blood is in such a dissolved state, that bleeding must be accounted highly pernicious. Nevertheless, it is indispensably necessary in the beginning of the distemper; and if omitted at that time, the violent heat and motion of the blood increase the putrescence of the humours to such a degree as to bring on fatal consequences much sooner than would otherwise have happened. If blood-letting be thus advised by Dr Hilary, it has been still more strongly recommended by Dr Rush, who, in his first publication on the subject of the dreadful yellow fever which proved so fatal at Philadelphia, represented it as an almost infallible remedy for the disease. But the observations and experience of others have by no means confirmed the practice which he recommended.

After bleeding, we come to the second indication of cure, namely, to evacuate as much of the bilious and putrid humours as soon and as safely as we can. The great irritation of the stomach, by the putrid bilious humours constantly attending this fever, with almost continual retchings and violent vomitings, seem to indicate the giving of an emetic: but the stomach is always observed to be so violently stimulated and irritated, and most commonly inflamed, by the acrimony of the putrescent bile, that any emetic, even the most mild and gentle, given in the smallest dose, brings on an incessant vomiting, which continues in spite of all remedies, till a mortification and death ensue. Instead of this, it is proper to give large draughts of warm water, which, without any additional stimulus to the stomach, evacuates its acrid and putrid contents, commonly with great relief to the patient: the warm water also acts as an emollient fotus to the inflamed coats of the stomach; and thus abates the inflammation, and prevents gangrene and mortification from coming on.

After the patient has by this means vomited seven or eight times, or oftener, and discharged a great quantity of yellow and blackish bilious matter, a grain or a grain and a half of thebaic extract is given, in order to procure some respite from the violent retching, vomiting, and anxiety. The person is desired to take nothing into his stomach for two hours after this, by which means it is seldom or never rejected; and thus all the symptoms are considerably abated, the retching and vomiting either totally cease or are very much lessened, so that medicines may now be exhibited which the stomach would not have retained before. These are cooling acid juleps, or other antiseptic remedies; but neither nitre nor any of its preparations will commonly be found to stay on the stomach, nor, according to Dr Hilary, are the nitrous medicines, or even the common antiemetic draughts, proper to be given in this disease, even though they should agree with the stomach, on account of their attenuating property.

If the patient has not a stool or two after drinking the warm water and vomiting, it is necessary to give a gentle purging clyster; and when six or eight hours rest have been obtained, a gentle antiphlogistic and antiseptic purge, in order to evacuate by stool as much of the bilious matter as we possibly can. Or if the patient has a purging before, which sometimes though very rarely happens, a dose of toasted rhubarb is given, and an antiseptic anodyne after it has operated, to abate and check the too great purging, but not to stop it, as this evacuation has been always observed to be of service, provided it be not very violent.

After this indication is completely answered, the next is to exhibit such proper antiseptic medicines as may stop the putrescent disposition of the fluids. Here the cinchona would seem to be the most proper remedy; but unluckily the stomachs of the patients in this disease are so much irritated, and so apt to reject every thing, that it cannot be retained in any form whatever. In this case Dr Percival recommends columbo root, the infusion of which is found to be a powerful antiemetic and antiputrescent medicine, and might perhaps so far alter the state of the stomach as to make it bear the bark. Dr Hilary, however, who was ignorant of the virtues of columbo, substituted the *radix serpentariæ Virginianæ* with success. A slight infusion of this root not only sat easily on the stomach of the patients, but moderately raised the pulse and fever, both of which are now too low. The following receipt was found the most agreeable and efficacious:

℞ Rad. serpent. Virginian. ℥ij.
Croc. Ang. ʒss. M. et infunde vase clauso in aq. bul. q. per horam unam ut col. ℥vj. Adde aq. menth. simp. ℥ij. Vin. Maderiens. ℥iv. Syr. croc. vel syr. è mecon. ℥i. Elix. vitriol. acid. q. s. ad grat. acid. sap. Exhibe cochlearia duo vel tria singulis horis vel bihoris, vel sæpius pro re nata.

By the use of this medicine, and soft light nourishment taken in small quantities, the pulse is usually kept up

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up and the distemper goes off. But if, after taking this a little while, we find that the pulse does not rise, but on the contrary that a coldness of the extreme parts comes on, the medicines must be made more warming, by increasing the quantity of the snakeroot and saffron, or by adding *vinum croceum*, *confectio cardiaca*, or the like, but not by the use of volatile spirits and salts, which hurt by their stimulating and dissolving qualities. Blisters Dr Hilary reprobates in the strongest terms, and affirms that he has seen the place where a blister was applied turned perfectly black and sphacelated; so that if the spine and end of the ribs had not hindered, a large square passage would have been opened into the cavity of the thorax, had the patient lived a few hours after it.

At the same time that the strength of the patient is kept up by the medicines above mentioned, or by others similar, he gave repeated gentle purgatives every second or third day, and sometimes, when the symptoms were very urgent, every day, for four or five days successively. But if proper methods be taken in the beginning of the disease, it is seldom that such a repetition of purging is necessary.

Dr Hilary's plan of treating the yellow fever is, in our opinion, as judicious as any that has yet been proposed. But, among the late writers, some have recommended mercury, particularly under the form of calomel, as the most efficacious remedy which can be employed. In some cases it has certainly been given to an almost incredible extent, in a very short time, without exciting either purging or salivation. And it cannot be denied, that patients have not unfrequently recovered under the use of it. But calomel can no more be reckoned an infallible remedy for this disease than blood-letting.

Since the introduction of cold affusion, in the cure of typhus fevers, by Dr Currie, it has been imagined by some, that this practice would afford a very efficacious remedy in the typhus icteroides, as well as in the typhus mitior. But experience has not yet confirmed the utility of this practice.

Some have suggested the internal use of the oxygenated muriatic acid, properly diluted, as an article from which great benefit may be expected in the yellow fever. This practice deserves, we think, a fair trial: but the utility of it still remains to be determined by experience.

To the genus of *typhus* also belong all those fevers attended with very profuse and debilitating sweats, and which have sometimes, not without good reason, been accounted plagues; such as the English sweating-sickness, Miliaris sudatoria, *Sauv.* sp. 5. Ephemera sudatoria, *Sauv.* sp. 7. Ephemera Britannica, *Caius de ephem. Britan.*

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Genus VI. SYNOCHUS.

Synochus, *Sauv.* gen. 81. *Lin.* 13.
Lenta, *Lin.* 14.
Phrenitis, *Vog.* 18.
Febris continua putrida, *Boerh.* 730.

This is a contagious distemper, being a complication of a synocha and typhus; for the description and cure of which, we must of consequence refer to what hath been already said concerning these diseases.

The *Hectic* Fever.

Hect

Hectica, *Sauv.* gen. 83. *Lin.* 24. *Vog.* 80. *Sag.* 684. 16

This disease is reckoned by Dr Cullen to be merely symptomatic; as indeed seems very probable, since it generally accompanies absorption of pus into the blood from internal suppurations, or indeed from such as are external, provided they be very large or of a bad kind.

Description. The best, perhaps the only proper, description of this disorder we have is that by Dr Heberden. According to him, the appearance of the hectic fever is not unlike that of the genuine intermittent; from which, however, the disease is very different in its nature, while at the same time it is much more dangerous. In the true intermittent, the three stages of cold, heat, and sweat, are far more distinctly marked, the whole fit is much longer, the period which it observes is more constant and regular, and the intermissions are more perfect, than in the hectic fever. For in the latter, even during the clearest remission, there is usually a feverish quickness perceptible in the pulse, which seldom fails to exceed the utmost limit of a healthy one by at least 10 strokes in a minute.

The chilness of the hectic fever is sometimes succeeded by heat, and sometimes immediately by a sweat without any intermediate state of heat. The heat will sometimes come on without any remarkable chilness preceding; and the chilness has been observed to go off without being followed either by heat or sweat. The duration of these stages is seldom the same for three fits together; and as it is not uncommon for one of them to be wanting, the length of the whole fit must vary much more than in the true intermittent; but in general it is much shorter.

A patient subjected to hectic fever is little or nothing relieved by the occurrence of the sweat; but is often as anxious and restless under it as during the chilness or heat. When the sweat is over, the fever will sometimes continue; and in the middle of the fever the chilness will return; which is a most certain mark of this disease.

The hectic fever will return with great exactness, like an intermittent, for two or perhaps three fits; but Dr Heberden informs us, that he does not remember ever to have known it keep the same period for four fits successively. The paroxysm will now and then keep off for 10 or 12 days; and at other times, especially when the patient is very ill, it will return so frequently on the same day, that the chilness of a new fit will follow immediately the sweat of the former. It is not unusual to have many threatenings of a shivering in the same day; and some degree of drowsiness is apt to attend the cessation of a fit.

The urine in a true intermittent is clear during the fits and turbid during the intervals; but in the hectic fever it is liable to all kinds of irregularity. It will be equally clear or turbid in both stages; or turbid in the fits and clear in the intervals; and sometimes it will be, as in a true intermittent, clear during the fever, and thick at the going off.

Hectic patients often complain of pains like those of the rheumatism, which either affect by turns almost every

every part of the body, or else return constantly to the same part; which is often at a great distance from the seat of the principal disorder, and, as far as is known, without any peculiar connection with it. Those pains are so violent in some patients, as to require a large quantity of opium. As far as Dr Heberden has observed, they are most common where the hectic arises from some ulcer open to the external air, as in cancers of the face, breast, &c. Joined with this fever, and arising probably from one common cause, he has been surprised to see swellings of the limbs, neck, or trunk of the body, rise up almost in an instant, as if the part was all at once grown fatter. These swellings are not painful, hard, or discoloured, and they continue for several hours.

Dr Heberden has seen this fever attack those who seemed in tolerable health, in a sudden and violent manner, like a common inflammatory one; and like that, also, in a very short time bring them into imminent danger of their lives; after which it has begun to abate, and to afford hopes of a perfect recovery. But though the danger might be over for the present, and but little of a fever remain; yet that little has soon demonstrated, that it was kept up by some great mischief within, and, proving unconquerable by any remedies, has gradually undermined the health of the patient, and never ceased except with his life. This manner of its beginning, however, is a rare occurrence. It much oftener dissembles its strength at first; and creeps on so slowly, that the subjects of it, though they be not perfectly well, yet for some months hardly think themselves ill; complaining only of being sooner tired with exercise than usual, of want of appetite, and of falling away. But gentle as the symptoms may seem, if the pulse be quicker than ordinary, so as to have the artery to beat 90 times and perhaps 120 times in a minute, there is the greatest reason to be apprehensive of the event. In no disorder, perhaps, is the pulse of more use to guide our judgment than in the hectic fever: yet even here we must be upon our guard, and not trust entirely to this criterion; for one in about twenty patients, with all the worst signs of decay from some incurable cause, which irresistibly goes on to destroy his life, will show not the smallest degree of quickness, nor any other irregularity of the pulse, to the day of his death.

Causes, &c. This fever will supervene whenever there is a great collection of matter formed in any part of the body; but it more particularly attends upon the inflammation of a scirrhous gland, and even upon one that is slight and only just beginning; the fever growing worse in proportion as the gland becomes more inflamed, ulcerated, or gangrenous. And such is the lingering nature of those glandular disorders, that the first of those stages will continue for many months, and the second for some years.

If this scirrhous inflammation be external, or in the lungs, or some of the abdominal viscera, where the disturbance of their functions plainly points out the seat of the disorder, no doubt can be entertained concerning the cause of the fever. But if the part affected be not obvious to the senses, and its precise functions be not known, the hectic, which is there only part of the train of another disease, may be mistaken for the primary or only affection.

Hectica.

Lying-in-women, on account of the violence sustained in delivery, generally die when affected with this fever. Women of the age of near 50 and upwards are particularly liable to it. For, upon the cessation of their natural discharge, the glands of the breasts, ovaries, or womb, too commonly begin to grow scirrhous, and proceed to be cancerous. Not only these, but the glandular parts of all the abdominal viscera, are supposed to be affected at this particular time, and to become the seats of incurable disorders.

The injuries done to the stomach and liver by hard drinking are attended with similar symptoms, and terminate in the same manner.

Dr Heberden observes, that the slightest wound by a fine-pointed instrument is known upon some occasions to bring on the greatest disturbances, and the most alarming symptoms, nay even death itself. For not only the wounded part will swell and be painful, but by turns almost every part of the body; and very distant parts have been known to come even to suppuration. These symptoms are constantly accompanied with this irregular intermittent, which lasts as long as any of them remain.

Prognosis. This anomalous fever is never less dangerous than when it originates from a kindly suppuration, into which all the diseased parts are melted down, and for which there is a proper outlet.

The symptoms and danger from some small punctures, with their concomitant fever, most frequently give way in a few days; though in some persons they have continued for two or three months, and in others have proved fatal.

The inflammation of internal scirrhous glands, or of those in the breasts, sometimes goes off, and the fever, which depended upon it, ceases; but it much oftener happens, that it proceeds to cancerous and gangrenous ulcers, and terminates only in death. Death is also, almost universally, the consequence of hectic fever from tubercles of the lungs, which have in general at least been considered as glandular bodies in a scirrhous state.

Cure. It is not to be expected that the same remedies will in every case be adapted to a fever which, arising from very different causes, is attended with such a variety of symptoms. A mixture of asafœtida and opium has insome persons seemed singularly serviceable in this fever, when brought on by a small wound; but in most other cases the principal if not the sole attention of the physician must be employed in relieving the symptoms, by tempering the heat, by preventing both costiveness and purging, by procuring sleep, and by checking the sweats. If, at the same time, continues Dr Heberden, he put the body into as good general health as may be, by air, exercise, and a proper course of mild diet, he can perhaps do nothing better than to leave all the rest to nature. In some few fortunate patients, nature appears to have such resources, as may afford reason for entertaining hopes of cure, even in very bad cases. For some have recovered from this fever attended with every symptom of an abdominal viscus incurably diseased, after all probable methods of relief from art had been tried in vain, and after the flesh and strength were so exhausted as to leave scarce any hopes from nature. In those deplorable

Phlegmasiæ.

ble circumstances, there has arisen a swelling not far from the probable seat of the disorder, and yet without any discoverable communication with it. This swelling has come to an abscess; in consequence of which the pulse has soon returned to its natural state, as have also the appetite, flesh, and strength. What nature has performed in those rare cases, Dr Heberden acquaints us, he has often endeavoured to imitate, by making issues or applying blisters near the seat of the disease; but he cannot say with the same success.

It seems at present, Dr Heberden observes, to be the opinion of many practitioners, that gangrenes will be stopped, and suppuration become more kindly, by the use of Peruvian bark; and therefore this remedy is always either advised or permitted in the irregular fever joined with suppurations and gangrenes. But he affirms he does not remember ever to have seen any good effect from cinchona in this fever unattended with an apparent ulcer; and even in gangrenes it so often fails, that in successful cases, where it has been administered, there must be room for suspicion that the success was owing to another cause. Dr Heberden acknowledges, at the same time, that he never saw any harm from cinchona, in these, or indeed in any other cases, except a slight temporary purging or sickness, where it has happened to disagree with the stomach, or where the latter has been loaded by taking the medicine too fast, especially in dry boluses wrapped in wafer-paper.

In hectic illnesses, where all other means have proved ineffectual, a journey to Bath is usually proposed by the friends, and wished for by the sick; but Dr Heberden justly observes, that, besides the fatigue and many inconveniences of a journey to a dying person, the Bath waters are peculiarly hurtful in this fever, which they never fail to increase, and thereby aggravate the sufferings and hasten the death of the patient.

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ORDER II. PHLEGMASIÆ.

Phlegmasiæ membranosæ et parenchymatosæ, *Sauv.* Class III. Ord. I. II. *Sag.* 605.
Morbi febriles phlogistici, *Lin.* Class III.
Febres continuæ compositæ inflammatoriæ, *Vog.*
Morbi acuti febriles, *Boerh.* 770.
Febres inflammatoriæ, *Hoffm.* II. 105. *Junck.* 61.

The phlegmasiæ, or topical inflammations, are a very numerous assemblage of diseases. Their great characteristics are, the general symptoms of fever, and a topical inflammation, attended with the lesion of some important function. In most instances, when blood is drawn, it is found upon coagulation to be covered with a buffy coat. Under this order, many important genera are comprehended, each requiring a separate consideration.

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GENUS VII. PHLOGOSIS.

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Sp. I. PHLOGOSIS PHLEGMONE.

Phlegmone auctorum, *Sauv.* gen. 15. *Lin.* 39. *Vog.* 351.
Inflammatio, *Lin.* 231. *Boerh.* 370. *Junck.* 20.

This disease is a synocha fever, accompanied with an inflammation of some particular part either external or internal, and consequently it varies very much in its form and the degree of danger attending it, according to the situation and functions of the part affected with topical inflammation. To this species, therefore, belong the following diseases:

Phlogosis.

Furunculus, *Sauv.* gen. 18. *Vog.* 352.
Terminthus, *Vog.* 381.
Pupula, *Lin.* 275. *Sauv.* p. 6.
Varus, *Vog.* 436. *Lin.* 269. *Sauv.* p. 7.
Bacchia, *Lin.* 270.
Gutta rosea, *Sauv.* gen. 4.
Gutta rosacea, *Vog.* 437.
Hordeolum, *Sauv.* gen. 27. *Lin.* 276. *Vog.* 434.
Otalgia, *Sauv.* gen. 197. *Lin.* 44. *Vog.* 148.
Dolor otalgicus, *Hoffm.* II. 336.
Parulis, *Vog.* 362.
Mastodynia, *Sauv.* gen. 210. *Vog.* 153.
Paronychia, *Sauv.* gen. 21. *Lin.* 258. *Vog.* 345.
Arthrocace, *Sauv.* gen. 78. *Lin.* 256.
Pædarthrocace, *Vog.* 419.
Spina ventosa, *Boerh.* 526.
Phimosis, *Sauv.* gen. 22. *Lin.* 297. *Vog.* 348.
Paraphimosis, *Vog.* 349.

For the cure of inflammations, Dr Cullen lays down the following indications. 1. To remove the remote causes when they are evident and continue to operate. 2. To take off the phlogistic diathesis affecting the whole system, or the particular part. 3. To take off the spasm of the particular part, by remedies applied to the whole system, or to the part itself.

The means of removing the remote causes will readily occur, from considering the particular nature and circumstances of the different kinds. Acrid matters must be removed, or their action must be prevented, by the application of demulcents. Compressing and overstretching powers must be taken away; and from their several circumstances, the means of doing so will be obvious.

The means of taking off the phlogistic diathesis of the system are the same with those already mentioned under the cure for synocha. The means of taking off the spasm also from the particular part, are much the same with those already mentioned. Only it is to be remembered, that topical bleedings, such as cupping with scarifications, applying leeches, &c. are in this case much more indicated; and that some of the other remedies are to be directed more particularly to the part affected, as shall be more fully considered when we treat of those diseases attended with particular inflammations.

When a tendency to suppuration is perceived, the proper indication is to promote the production of perfect pus as much as possible. For this purpose various remedies, supposed to possess a specific power, have been proposed: but it does not appear that any of them are possessed of a virtue of this kind; and, in Dr Cullen's opinion, all that can be done is to favour the suppuration by such applications as may support a moderate heat in the part, by some tenacity confine the perspiration, and by an emollient quality may weaken the cohesion of the teguments, and favour their erosion. As all abscesses are occasioned by the effusion of fluids, and as in the case of certain effusions a suppuration becomes

comes not only unavoidable but desirable, it may be supposed that most of the means of procuring a resolution, by diminishing the force of circulation, &c. ought to be avoided. But as we observe, on the one hand, that a certain degree of increased impetus, or of the original symptoms of inflammation, is necessary to produce a proper suppuration; so it is then especially necessary to avoid those means of resolution which may diminish too much the force of circulation. And on the other hand, as the impetus of the blood, when violent, is found to prevent the proper suppuration; so, in such cases, though a tendency to suppuration may have begun, it may be proper to continue those means of resolution which moderate the force of the circulation. With respect to the opening of abscesses when completely formed, see the article SURGERY.

When an inflammation has taken a tendency to gangrene, that event is to be prevented by every possible means; and these must be different according to the nature of the several causes: but after a gangrene has in some degree taken place, it can be cured only by the separation of the dead from the living parts. This in certain circumstances can be performed, and most properly, by the knife. In other cases it can be done by exciting a suppuratory inflammation on the verge of the living part, whereby its cohesion with the dead part may be everywhere broken off, so that the latter may fall off by itself. While this is doing, it is proper to prevent the further putrefaction of the part, and its spreading wider. For this purpose various antiseptic applications have been proposed: but Dr Cullen is of opinion, that while the teguments are entire, these applications can hardly have any effect; and therefore that the fundamental procedure must be to scarify the part so as to reach the living substance, and, by the wounds made there, to excite the suppuration required. By the same incisions also we give access to antiseptics, which may both prevent the progress of the putrefaction in the dead, and excite the inflammation necessary on the verge of the living parts.

When the gangrene proceeds from loss of tone, and when this, communicated to the neighbouring parts, prevents that inflammation which, as we have said, is requisite to the separation of the dead parts from the living, it will be necessary to obviate this loss of tone by tonic medicines given internally; and for this purpose cinchona has been found to be most effectual. But when the gangrene arises from the violence of inflammation, the bark may not only fail of proving a remedy, but may do harm: for its power as a tonic is especially suited to those cases of gangrene which proceed from an original loss of tone, as in the case of palsy and œdema; or in those cases where a loss of tone takes place after the original inflammatory symptoms are removed.

On the other hand, Mr Bell is of opinion, that incisions made with a view to admit the operation of antiseptic remedies in gangrenes, as well as the remedies themselves, must be pernicious from the irritation they occasion, and from the danger of wounding bloodvessels, nerves, or tendons, and also by allowing a free passage for the putrescent fluids into the parts not yet affected. And unless they be carried so deep as to reach the sound parts, applications of the antiseptic kind can never have any effect in answering the purpose for which they were intended. The same author also remarks, that all the advantages commonly observed from the great number of applications recommended for gangrene, are obtained with more ease, and generally too with more certainty, from the use of some gentle stimulating embrocation; which, by exciting a slight irritation upon the surface, especially when assisted by a free use of cinchona, produces for the most part such a degree of inflammation as is wished for. With this view he has frequently known a weak solution of sal ammoniac, a dram of the salt to two ounces of vinegar and six of water, form a mixture of very proper strength for every purpose of this kind. But the degree of stimulus can easily be either increased or diminished according to circumstances, by using a larger or smaller proportion of the salt.

Whenever, either by the means recommended, or by a natural exertion of the system, a slight inflammation appears between the diseased and sound parts, we may in general, with tolerable certainty, expect, that in due time the parts will be separated; and when a full suppuration is once fairly established, there can be little doubt that the mortified parts will be soon and easily removed.

A complete separation being effected, the sore is to be treated in the manner described under the article SURGERY; with a proper attention, at the same time, to the support of the general system by the continuance of nourishing diet, and cinchona with such quantities of wine as may seem necessary.

With regard to the bark, however, it is proper to take notice of another case of mortification in which it is likewise unsuccessful, as well as in that attended with a high degree of inflammation; and that is, in those mortifications of the toes and feet, common in old people, or which arise from any cause increasing the rigidity of the vessels to such a degree as to prevent the motion of the fluids through them. In this case Mr Pott has discovered, that all kinds of warm applications are very unsuccessful; but by the free use of opium, together with sedatives and relaxants externally applied, he has frequently seen the tumefaction of the feet and ankles subside, the skin recover its natural colour, and all the mortified parts separate in a very short time, leaving a clean sore. But as to scarifications, or any other attempt to separate artificially the mortified from the sound parts, he thinks them very prejudicial, by giving pain; which is generally of itself violent in this disease, and which seems to have a great share in producing the other evils.

The other terminations of inflammation either do not admit of any treatment except that of preventing them by resolution, or properly belong to the article SURGERY.

Sp. II. PHLOGOSIS ERYTHEMA.

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Erythema, *Sauv.* gen. 11.
 Erysipelas auctorum, *Vog.* 343.
 Hieropyr. *Vog.* 344.
Anthrax, *Sauv.* gen. 19. *Lin.* 272. *Vog.* 353.
 Carbo et carbunculus auctorum.
 Erythema gangrænosum, *Sauv.* sp. 7.
Erythema à frigore.
 Erythema pernio, *Sauv.* sp. 4.
 Pernio, *Lin.* 259. *Vog.* 350.

Erythema

Phlegmasiæ.

Erythema ambustio, *Sauv.* sp. 2.
Erysipelas ambustio, *Sauv.* sp. 4.
Combustura, *Lin.* 245.
Combustio, *Boerh.* 476.
Encausis, *Vog.* 347.
Erythema ab acri alieno applicato.
Erysipelas Sinense, *Sauv.* sp. 7.
Erythema ab acri inquilino.
Erythema intertrigo, *Sauv.* sp. 5.
Intertrigo, *Lin.* 247. *Vog.* 502.
Erythema à compressione.
Erythema paratrima, *Sauv.* sp. 6.
Erythema à puncturâ, *Sauv.* sp. 9.
Erysipelas à vespis, *Sauv.* sp. 19.
Psydracia à vespis, *Sauv.* sp. 2.
Erythema cum phlegmone.
Erysipelas phlegmonodes auctorum.
Erythema cum œdemate.
Erysipelas symptomaticum, *Sauv.* sp. 6.

The word *erythema* does not apply to any primary disease, but to a great number of those cutaneous inflammations denominated by another general term, viz. the *erysipelas*, or "St Anthony's fire;" and which being commonly symptomatic of some other inflammation or disorder, are to be removed only by removing the primary disease: the erythema is found scarcely to bear any kind of warm application to itself; and is very apt, if treated as a primary disease, to terminate in a gangrene of the part affected, or some other disorder still more dangerous. The difference between the *phlegmon* or preceding species, and *erythema*, according to Dr Cullen, is, that, in the former, the inflammation seems particularly to affect the vessels on the internal surface of the skin, communicating with the lax adjacent cellular texture; whence a more copious effusion, and that too of serum convertible into pus, takes place. In the erythema the affection is of the vessels on the external surface of the skin communicating with the *rete mucosum*. This affection does not admit of any effusion but what separates the cuticle, and gives occasion to the formation of a blister, while the smaller size of the vessels admits only of the effusion of a thin fluid very seldom convertible into pus. For the cure of the fever attended with erythema or *erysipelas*, see below; and for the external treatment of erythema, see Surgery.

174 Genus VIII. OPHTHALMIA.

Inflammation of the Eyes.

Ophthalmia, *Sauv.* gen. 196. *Lin.* 43. *Vog.* 341. *Sag.* 231. *Junck.* 24.
Chemosis, *Vog.* 46.
Ophthalmites, *Vog.* 47.
Inflammatio oculorum, *Hoffm.* II. 165.
Ophthalmia taraxis, *Sauv.* sp. 1.
Ophthalmia humida, *Sauv.* sp. 8.
Ophthalmia chemosis, *Sauv.* sp. 12.
Ophthalmia erysipelatosa, *Sauv.* sp. 7.
Ophthalmia pustulosa, *Sauv.* sp. 6.
Ophthalmia phlyctænodes, *Sauv.* sp. 21.
Ophthalmia choroeidea, *Sauv.* sp. 13.
Ophthalmia tenebricosa, *Sauv.* sp. 10.
Ophthalmia trachoma, *Sauv.* sp. 4.
Ophthalmia sicca, *Sauv.* sp. 5.
Ophthalmia angularis, *Sauv.* sp. 14.
Ophthalmia tuberculosa, *Sauv.* sp. 3.
Ophthalmia trichiasis, *Sauv.* sp. 2.
Ophthalmia cancrosa, *Sauv.* sp. 15.
Ophthalmia à synechiâ, *Sauv.* sp. 16.
Ophthalmia à lagophthalmo, *Sauv.* 17.
Ophthalmia ab elcomate, *Sauv.* sp. 18.
Ophthalmia ab ungue, *Sauv.* sp. 19.
Ophthalmia à corneæ fistulâ, *Sauv.* sp. 20.
Ophthalmia uveæ, *Sauv.* sp. 22.
Ophthalmia metastatica, *Sauv.* sp. 24.
Ophthalmia scrophulosa, *Sauv.* sp. 9.
Ophthalmia siphylitica, *Sauv.* sp. 11.
Ophthalmia febricosa, *Sauv.* sp. 23.

From reading this long list of distinctions which authors have invented in the ophthalmia, it is evident, that by far the greatest part of them are symptomatic, or merely the consequence of other disorders present in the habit; and therefore the remedies must be directed towards the removal of these primary disorders; and when they are gone the ophthalmia will be removed of course. Dr Cullen observes, that the inflammation of the eye may be considered as of two kinds; according as it is seated in the membranes of the ball of the eye, when it is named *ophthalmia membranarum;* or as it is seated in the sebaceous glands placed in the tarsus, or edges of the eyelids, in which case it may be termed *ophthalmia tarsi*. These two kinds are very frequently connected together, as the one may excite the other; but they are still to be distinguished according as the one or the other may happen to be the primary affection.

1. The inflammation of the *membranes* of the eye affects especially, and most frequently, the adnata, and appears in a turgescence of its vessels; so that the red vessels which are naturally there, become not only increased in size, but many more appear than in a natural state. This turgescence of the vessels is attended with pain, especially upon the motion of the ball of the eye; and this irritation, like every other, applied to the surface of the eye, produces an effusion of tears from the lachrymal gland.

The inflammation commonly, and chiefly, affects the adnata spread on the anterior part of the bulb of the eye; but usually spreads also along the continuation of the adnata on the inside of the palpebræ; and as that is extended on the tarsus palpebrarum, the excretories of the sebaceous glands opening there are also frequently affected. When the affection of the adnata is considerable, it may be communicated to the subjacent membranes of the eye, and even to the retina itself; which thereby acquires so great sensibility, that every impression of light becomes painful. The inflammation of the membranes of the eye is in different degrees, according as the adnata is more or less affected, or according as the inflammation is either of the adnata alone, or of the subjacent membranes also; and upon these differences, different species have been established; but they seem all to differ only in degree, and are to be cured by the same remedies more or less employed.

The proximate cause of ophthalmia is not different from that of inflammation in general; and the different circumstances of ophthalmia may be explained

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by the difference of its remote causes, and by the different parts of the eye which it happens to affect; as may be understood from what has been already said. We shall therefore proceed to give an account of the method of cure.

The great objects to be aimed at in the treatment of ophthalmia, are, in the first place, the resolution of the inflammation which has already taken place; and, secondly, the removal of those consequences which frequently arise from the inflammation, especially if it have been of long standing. But besides these, while it has appeared from former observation, that there is a peculiar disposition to the disease, practices may often be successfully employed to combat this disposition, and thus prevent the return of the affection.

The ophthalmia membranarum requires the remedies proper for inflammation in general; and when the deeper-seated membranes are affected, and especially when a pyrexia is present, large general bleedings may be necessary. But this last is seldom requisite, and, for the most part, the ophthalmia is an affection merely local, accompanied with little or no pyrexia. General bleedings therefore have little effect upon it, and the cure is chiefly to be obtained by topical bleedings, that is, blood drawn from the vessels near the inflamed part; and opening the jugular vein, or the temporal artery, may be considered as in some measure of this kind. It is commonly sufficient to apply a number of leeches round the eye; but it is perhaps still better to draw blood by cupping and scarifying from the temples. In many cases, the most effectual remedy is to scarify the internal surface of the inferior eyelid, and to cut the turgid vessels upon the adnata itself.

Besides blood-letting, purging, as a remedy suited to inflammation in general, has been considered as peculiarly adapted to inflammation in any part of the head, and therefore to ophthalmia; and it is sometimes useful: but, for the reasons given before with respect to general bleeding, purging in the case of ophthalmia does not prove useful in any proportion to the evacuation excited.—For relaxing the spasm in the part, and taking off the determination of the fluids to it, blistering near the part has commonly been found useful. When the inflammation does not yield to the application of blisters after topical bleeding, great benefit is often obtained by supporting a discharge from the blistered part, under the form of an issue, by which means a more permanent determination of blood from the part is obtained.

It is probably also on the same principle that the good effects obtained from the use of errhine medicines in obstinate cases of ophthalmia are to be accounted for. By these errhines, in particular, which occasion and support for some time a great discharge from the nose, great benefit has often been obtained. The powder of asarabacca, or the infusion of hippocastanum, snuffed up the nose at bedtime in proper doses, are often productive of the best effects, when many other remedies have been tried in vain.

Ophthalmia, as an external inflammation, admits of topical applications. All those, however, which increase the heat and relax the vessels of the part, prove hurtful; and the admission of cool air to the eye, and the application of cooling and astringent medicines, which at the same time do not produce irritation, prove useful. Of all these the solution of acetite of lead, assiduously applied, is perhaps the best. In the cure of this distemper, indeed, all irritation must carefully be avoided, particularly that of light; and the only certain means of doing this is by keeping the patient in a very dark chamber.

2. In the *ophthalmia tarsi*, the same medicines may be necessary, as have been already recommended for the ophthalmia membranarum. However, as the ophthalmia tarsi may often depend upon an acrimony deposited in the sebaceous glands of the part, so it may require various internal remedies according to the variety of the acrimony in fault; for which we must refer to the consideration of scrophula, siphylis, or other diseases with which this ophthalmia may be connected; and where these shall not be evident, certain remedies more generally adapted to the evacuation of acrimony, such as mercury, may be employed. In the ophthalmia tarsi, it almost constantly happens that some ulcerations are formed on the tarsus. These require the application of mercury and copper, which alone may sometimes cure the whole affection: and they may be useful even when the disease depends upon a fault of the whole system.

Both in the ophthalmia membranarum, and in the ophthalmia tarsi, it is necessary to obviate that gluing together of the eyelids which commonly happens in sleep; and which may be done by insinuating a little of any mild unctuous medicine between the eyelids before the patient shall go to sleep.

The slighter kinds of inflammations from the dust or the sun, may be removed by fomenting with warm milk and water, adding a small portion of brandy; and by anointing the borders of the eyelids with *unguentum tutiæ*, or the like, at night, especially when those parts are excoriated and sore. But in bad cases, after the inflammation has yielded a little to evacuations, the *cataplasma aluminis* of the London Pharmacopœia spread on lint, and applied at bedtime, has been found the best external remedy. Before the use of the latter, the solution of sulphate of zinc is prescribed with advantage; and in violent pains it is of service to foment frequently with a decoction of white poppy-heads. One of the most common and most disagreeable consequences of ophthalmia, is an offuscation of the cornea, so far obstructing the passage of light as to diminish or prevent vision. This is sometimes so considerable as to admit of removal by operation: but in slighter cases it may often be removed by the application of different gentle escharotics; and in this way, without the least danger of any inconvenience, goods effects are often obtained, from gently introducing into the eye at bedtime a powder consisting of equal parts of supertartrite of potass and sugar, reduced together to a fine powder.

Where there is a disposition to frequent returns of this affection, cinchona is often employed with success in combating it: But nothing in general answers better than frequent and regular cold bathing of the eyes.

Besides the various species of ophthalmia which were before known in Britain, another has lately been introduced, that contagious ophthalmia, viz. with which the British

Phlegmasiæ. British troops were affected in Egypt, and which they have imported into this island on their return from thence.

Of this affection many interesting accounts have been published. Perhaps the best is an elaborate treatise by Mr Edmonston, who has had many opportunities of witnessing the affection, and extensive practice in the treatment of the disease, both in Egypt and in Britain. To his work therefore we may refer those who wish for the most full information respecting it. We shall only observe, that now, no doubt can be entertained respecting the contagious nature of the disease; and that therefore the first great object necessary in the treatment is the complete separation of the diseased from the sound.

175 GENUS IX. PHRENITIS.

PHRENSY, or *Inflammation of the BRAIN*.

Phrenitis, *Sauv.* gen. 101. *Lin.* 25. *Sag.* gen. 301. *Boerh.* 771. *Hoffm.* II. 131. *Junck.* 63.
Phrenismus, *Vog.* 45.
Cephalitis, *Sauv.* gen. 109. *Sag.* gen. 310.
Sphacelismus, *Lin.* 32.
Phrenitis vera, *Sauv.* sp. 1. *Boerh.* 771.
Phrenitis idiopathica, *Junck.* 63.
Cephalalgia inflammatoria, *Sauv.* sp. 9.
Cephalitis spontanea, *Sauv.* sp. 3.
Cephalitis siriasis, *Sauv.* sp. 4.
Siriasis, *Vog.* 34.
Cephalitis Littriana, *Sauv.* sp. 5.

Dr Cullen observes, that the true phrenitis, or inflammation of the membranes or substance of the brain, is very rare as an original disease: but, as a symptom of others, much more frequent; of which the following kinds are enumerated by different authors:

Phrenitis synochi pleuriticæ, *Sauv.* sp. 2.
Phrenitis synochi sanguineæ, *Sauv.* sp. 4.
Phrenitis calentura, *Sauv.* sp. 11.
Phrenitis Indica, *Sauv.* sp. 12.
Cephalitis Ægyptiaca, *Sauv.* sp. 1.
Cephalitis epidemica anno 1510, *Sauv.* sp. 6.
Cephalitis verminosa, *Sauv.* sp. 7.
Cephalitis cerebelli, *Sauv.* sp. 8.
Phrenitis miliaris, *Sauv.* sp. 3.
Phrenitis variolosa, *Sauv.* sp. 5.
Phrenitis morbillosa, *Sauv.* sp. 6.
Phrenitis à plicâ, *Sauv.* sp. 8.
Phrenitis aphrodisiaca, *Sauv.* sp. 9.
Phrenitis à tarantismo, *Sauv.* sp. 14.
Phrenitis hydrophobica, *Sauv.* sp. 15.
Phrenitis à dolore, *Sauv.* sp. 13.
Cephalitis traumatica, *Sauv.* sp. 2.

Description. The signs of an impending phrenitis are, immoderate and continual watchings; or if any sleep be obtained, it is disburbed with dreams, and gives no refreshment; acute and lasting pains, especially in the hind part of the head and neck; little thirst; a great and slow respiration, as if proceeding from the bottom of the breast; the pulse sometimes small and slow, sometimes quick and frequent; a suppression of urine; and forgetfulness. The distemper when present may be known by the following signs: The veins of the head swell, and the temporal arteries throb much; the eyes are fixed, sparkle, and have a fierce aspect; the speech is incoherent, and the patient behaves very roughly to the bystanders, with furious attempts to get out of bed, not indeed continually, but returning as it were by paroxysms: the tongue is dry, rough, yellow, or black; there is a coldness of the external parts; a proneness to anger; chattering of the teeth; a trembling of the hands, with which the sick seem to be gathering something, and actually do gather the naps off the bed-clothes.

Phrenitis. *Causes of, and persons subject to, this disorder.* People of a hot and bilious habit of body, and such as are of a passionate disposition, are apt to be affected with phrenitis. In the same danger are those who make much use of spices, or are given to hot and spirituous liquors; who have been exposed more than usual to the sun, or obliged to undergo immoderate studies or watchings; who are subject to headachs, or in whom some customary hemorrhages have been stopped; or the disease may arise from some injury offered to the head externally. Sir John Pringle observes, that the phrenitis, when considered as an original disease, is apt to attack soldiers in the summer season when they are exposed to the heat of the sun, and especially when asleep and in liquor. A symptomatic phrenitis is also more frequent in the army than elsewhere, on account of the violence done to all fevers when the sick are carried in waggons from the camp to the hospital, where the very noise or light alone would be sufficient, with more delicate natures, to raise a phrensy. From these and similar causes, a state of active inflammation, affecting some parts within the cranium, is produced: and there can be no doubt, that from this all the symptoms of the disease arise, and particularly that peculiar delirium which characterizes it. But in what manner local diseases, even of the brain itself, produce affections of the mind, we are still totally in the dark.

Prognosis. Every kind of phrenitis, whether idiopathic or symptomatic, is attended with a high degree of danger; and, unless removed before the fourth day, a gangrene or sphacelus of the meninges readily takes place, and the patient dies delirious. The following are the most fatal symptoms: A continual and furious delirium, with watching; thin watery urine, white fæces, the urine and stools running off involuntarily, or a total suppression of these excretions; a ready disposition to become stupid, or to faint; trembling, rigor, chattering of the teeth, convulsions, hiccough, coldness of the extremities, trembling of the tongue, shrill voice, a sudden cessation of pain, with apparent tranquillity. The following are favourable: Sweats, apparently critical, breaking out; a seeming effort of nature to terminate the disease by a diarrhœa; a large hemorrhagy from the nose; swellings of the glands behind the ears; hæmorrhoids.

Cure. From what has been said of the theory of this disease, the cure must entirely depend on obtaining a resolution of the inflammation. The objects chiefly to be aimed at with this view are, 1. The removal of such exciting causes as continue to operate. 2. The diminution of the momentum of the blood in the circulating system in general. 3. The diminution of impetus at the brain in particular: and, 4. The avoiding

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ing circumstances which tend either to accelerate the motion of the blood or to give determination to the head.

Different practices may be used with these intentions; but the most powerful remedies are to be immediately employed. Large and repeated bleedings are especially necessary; and these too taken from vessels as near as possible to the part affected. The opening the temporal artery has been recommended, and with some reason: but as the practice is attended with inconveniences, perhaps the opening of the jugular veins may in general prove more effectual; with which, however, may be joined the drawing of blood from the temples by cupping and scarifying. It is also probable, that purging may be of more use in this than in some other inflammatory affections, as it may operate by revulsion. For the same purpose of revulsion, warm pediluvia are a remedy, but rather ambiguous. The taking off the force of the blood in the vessels of the head by an erect posture is generally useful. Blistering is also useful, but chiefly when applied near to the part affected. In short, every part of the antiphlogistic regimen is here necessary, and particularly the admission of cold air. Even cold substances applied to the head have been found useful; and the application of such refrigerants as vinegar is certainly proper. Opiates are thought to be hurtful in every inflammatory state of the brain. On the whole, however, it must be remarked, that practitioners are very uncertain with regard to the means proper to be used in this disease; and the more so, that the symptoms by which the disease is commonly judged to be present, appear sometimes without any internal inflammation; and on the other hand, dissections have shown that the brain has been inflamed, where few of the peculiar symptoms of inflammation had appeared before death.

6 Genus X. CYNANCHE.

Cynanche, *Sauv.* gen. 110. *Lin.* 33. *Sag.* gen. 300.
Angina, *Vog.* 49. *Hoffm.* II. 125. *Junck.* 30.
Angina inflammatoria, *Boerh.* 798.

Sp. I. Cynanche tonsillaris.
7 The *Inflammatory* Quinsy.

Cynanche tonsillaris, *Sauv.* sp. 1.
Angina inflammatoria, sp. 5. *Boerh.* 805.

Description. This is an inflammation of the mucous membrane of the fauces, affecting principally that congeries of mucous follicles which forms the tonsils; and from thence spreading along the velum and uvula, so as frequently to affect every part of the mucous membrane. The disease appears by some tumour and redness of the parts; is attended with a painful and difficult deglutition; a troublesome clamminess of the mouth and throat; a frequent but difficult excretion of mucus; and the whole is accompanied with pyrexia. The inflammation and tumour are commonly at first most considerable in one tonsil; and afterwards, abating in that, increase in the other. This disease is not contagious.

Causes of, and persons subject to, this disorder. This disease is commonly occasioned by cold externally applied, particularly about the neck. It affects especially the young and sanguine; and a disposition to it is often acquired by habit. It occurs especially in the spring and autumn, when vicissitudes of heat and cold frequently take place.

Prognosis. This species of cynanche terminates frequently by resolution, sometimes by suppuration, but hardly ever by gangrene; though in some cases sloughy spots appear on the fauces: the prognosis therefore is generally favourable.

Cure. As the principal morbid affection in this disease, on which all its characterising symptoms immediately depend, is the active inflammation in the tonsils and neighbouring parts, the object first and principally to be aimed at in the cure is to obtain a resolution of this inflammation. Sometimes, however, it is necessary to have recourse to practices, with the view of obviating urgent symptoms before a resolution can be effected: and in other cases, where a resolution cannot be obtained, it must be the aim of the practitioner to promote a speedy and favourable suppuration. After suppuration has taken place, the proper means of promoting a discharge of the purulent matter will conclude the cure. Here some bleeding may be necessary; but large and general evacuations are seldom beneficial. The opening of the ranular veins is an insignificant remedy, according to Dr Cullen, but is recommended as efficacious by Sir John Pringle: more benefit, however, may in general be derived from leeches to the external fauces. The inflammation may be often relieved by moderate astringents, and particularly by acids applied to the parts affected. In many cases, nothing has been found to give more relief than the vapour of warm water received into the fauces.

Besides these, blistering, and still more frequently rubefacient medicines, are applied with success, as well as antiphlogistic purgatives; and every part of the antiphlogistic regimen is to be observed, except the application of cold. Sir John Pringle recommends a thick piece of flannel moistened with two parts of common sweet oil, and one of spirit of hartshorn (or in a larger proportion, if the skin will bear it), to be applied to the throat, and renewed once every four or five hours. By this means the neck, and sometimes the whole body, is put into a sweat, which after bleeding either carries off or lessens the inflammation. When the disease has a tendency to suppuration, nothing will be more useful than receiving into the fauces the steams of warm water. Benefit is also obtained from poultices applied to the external fauces. When the abscess is attended with much swelling, if it break not spontaneously, it ought to be opened by a lancet; and this does not require much caution, as even the inflammatory state may be relieved by some scarification of the tonsils. When this disease runs very rapidly to such a height as to threaten suffocation, it is sometimes necessary to have recourse to bronchotomy as the only means of saving the life of the patient. But there is reason to believe that this operation has sometimes been employed where it was not necessary: and we may safely venture to say, that it is but seldom requisite; insomuch that Dr Cullen tells us, he has never in his practice seen any case requiring bronchotomy.

Sp. II. Cynanche maligna. 178
The *malignant, putrid,* or *ulcerous* Sore Throat.

Cynanche maligna, *Sauv.* sp. 3.

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Cynanche ulcerosa, *Sauv.* var. a. Journ. de Med. 1758.

Cynanche gangrænosa, *Sauv.* var. b. Journ. de Med. 1756.

Ulcera faucium et gutturis anginosa et lethalia, Hispanis *Garrotillo, Lud. Mercat.* consult. 24.

Angina ulcerosa, *Fothergill's* Account of the ulcerous sore throat, edit. 1751. *Huxham* on the malignant ulcerous sore throat, from 1751 to 1753.

Febris epidemica cum angina ulcusculosa, *Douglas's* Practical History, Boston, 1736.

Angina epidemica, *Russel,* Oecon. Natur. p. 105.

Angina gangrænosa, *Withering's* Dissert. Inaug. Edinb. 1766.

Angina suffocativa, *Bard's* Inquiry, New York, 1771.

Angina maligna, *Johnstone* on the malignant Angina, Worcester, 1779.

History and Description. This distemper is not particularly described by the ancient physicians; though perhaps the Syrian and Egyptian ulcers mentioned by Aretæus Cappadox, and the pestilent ulcerated tonsils we read of in Aetius Amideus, were of this nature. Some of the scarlet fevers mentioned by Morton seem also to have approached near to it. In the beginning of the last century, a disease exactly similar to this is described by the physicians of that time, as raging with great violence and mortality in Spain and some parts of Italy; but no account of it was published in this country till the year 1748, when a very accurate one was drawn up by Dr Fothergill, and in 1752 by Dr Huxham. The latter observes, that this disease was preceded by long, cold, and wet seasons; by which probably the bodies of people were debilitated, and more apt to receive contagion, which possibly also might be produced by the stagnant and putrid waters.

The attack of this disease was very different in different persons. Sometimes a rigor, with fulness and soreness of the throat, and painful stiffness of the neck, were the first symptoms complained of. Sometimes alternate chills and heats, with some degree of giddiness, drowsiness, or headach, ushered in the distemper. It seized others with more severe feverish symptoms; great pain of the head, back, and limbs; a vast oppression of the præcordia, and continual sighing. Some grown persons went about for days in a drooping state, with much uneasiness and anxiety, till at last they were obliged to take to their beds.—Thus various was the disease, says Dr Huxham, at the onset. But it commonly began with chills and heats, load and pain of the head, soreness of throat, and hoarseness; some cough, sickness at stomach, frequent vomiting and purging, in children especially, which were sometimes very severe; though a contrary state was more common to the adult. There was in all a very great dejection of spirits, very sudden weakness, great heaviness on the breast, and faintness, from the very beginning. The pulse in general was quick, small, and fluttering, though sometimes heavy and undulating. The urine was commonly pale, thin, and crude; however, in many grown persons, it was passed in small quantities and high coloured, or like turbid whey. The eyes were heavy, reddish, and as it were weeping; the countenance very often full, flushed, and bloated, though sometimes pale and sunk.

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How slight soever the disorder might appear in the day-time, at night the symptoms became greatly aggravated, and the feverish habit very much increased, nay, sometimes a delirium occurred on the very first night; and this exacerbation constantly returned through the whole course of the disease. Indeed, when it was considerably on the decline, our author says he has been often pretty much surprised to find his patient had passed the whole night in a phrensy, whom he had left tolerably cool and sedate in the day.

Some few hours after the seizure, and sometimes cotemporary with it, a swelling and soreness of the throat was perceived, and the tonsils became very tumid and inflamed, and many times the parotid and maxillary glands swelled very much, and very suddenly, even at the very beginning; sometimes so much as even to threaten strangulation. The fauces also very soon appeared of a high florid red, or rather of a bright crimson, colour, very shining and glossy; and most commonly on the uvula, tonsils, velum palatinum, and back part of the pharynx, several whitish or ash-coloured spots appeared scattered up and down, which oftentimes increased very fast, and soon covered one or both the tonsils, uvula, &c.: those in the event proved sloughs of superficial ulcers (which sometimes, however, ate very deep into the parts). The tongue at this time, though only white and moist at the tip, was very foul at the root, and covered with a thick, yellowish or brown coat. The breath also now began to be very nauseous: which offensive smell increased hourly, and in some became at length intolerable, and that too sometimes even to the patients themselves.

The second or third day every symptom became much more aggravated, and the fever much more considerable; and those that had struggled with it tolerably well for 30 or 40 hours, were forced to submit. The restlessness and anxiety greatly increased, as well as the difficulty in swallowing. The head was very giddy, pained, and loaded; there was generally more or less of a delirium; sometimes a pervigilium and perpetual phrensy, though others lay very stupid, but often starting and muttering to themselves. The skin was very hot, dry, and rough; there was very rarely any disposition to sweat. The urine was pale, thin, crude; often yellowish and turbid. Sometimes vomiting was urgent, and sometimes a very great looseness, in children particularly. The sloughs were now much enlarged, and of a darker colour, and the surrounding parts tended much more to a livid hue. The breathing became much more difficult; with a kind of a rattling stertor, as if the patient was actually strangling, the voice being exceeding hoarse and hollow, exactly resembling that from venereal ulcers in the fauces: this noise in speaking and breathing was so peculiar, that any person in the least conversant with the disease might easily know it by this odd noise; from whence indeed the Spanish physicians gave it the name of *garrotillo,* expressing the noise made by persons when they are strangled with a rope. Dr Fothergill never observed in one of them the shrill barking noise that we frequently hear in inflammatory cynanche. The breath

Phlegmasiæ. breath of all the diseased was very nauseous; of some insufferably fetid, especially in the advance of the distemper to a crisis; and many about the fourth or fifth day spit off a vast quantity of stinking purulent mucus tinged sometimes with blood: and sometimes the matter was quite livid, and of an abominable smell. The nostrils likewise in many were greatly inflamed and excoriated, continually dripping down a very sharp ichor or sanious matter, so excessively acrid, that it not only corroded the lips, cheeks, and hands of the children that laboured under the disease, but even the fingers and arms of the very nurses that attended them: as this ulceration of the nostrils came on, it commonly caused an almost incessant sneezing in the children; but few adults were affected with it, at least to any considerable degree. It was surprising what quantities of matter some children discharged this way, which they would often rub on their face, hands, and arms, and blister them all over. A sudden stoppage of this rheum from the mouth and nostrils actually choaked several children; and some swallowed such quantities of it, as occasioned excoriations of the intestines, violent gripings, dysentery, &c. nay, even excoriations of the anus and buttocks. Not only the nostrils, fauces, &c. were greatly affected by the extremely sharp matter, but the wind-pipe itself was sometimes much corroded by it, and pieces of its internal membrane were spit up, with much blood and corruption; and the patients lingered on for a considerable time, and at length died tabid; though there were more frequent instances of its falling suddenly and violently on the lungs, and killing in a peripneumonic manner.

Dr Huxham was astonished sometimes to see several swallow with tolerable ease, though the tumour of the tonsils and throat, the quantity of thick mucus, and the rattling noise in breathing, were very terrible; which he thinks pretty clearly shows, that this malignant angina was more from the acrimony and abundance of the humours than the violence of the inflammation.

Most commonly the angina came on before the exanthemata; but many times the cuticular eruption appeared before the sore-throat, and was sometimes very considerable, though there was little or no pain in the fauces: on the contrary, a very severe angina seized some patients that had no manner of eruption; and yet, even in these cases, a very great itching and desquamation of the skin sometimes ensued; but this was chiefly in grown persons, very rarely in children. In general, however, a very considerable efflorescence broke out on the surface of the body, particularly in children; and it most commonly happened the second, third, or fourth day: sometimes it was partial, sometimes it covered almost the whole body, though very seldom the face: sometimes it was of an erysipelatous kind; sometimes more pustular: the pustules frequently eminent, and of a deep fiery red colour, particularly on the breast and arms; but oftentimes they were very small, and might be better felt than seen, and gave a very odd kind of roughness to the skin. The colour of the efflorescence was commonly of a crimson hue, or as if the skin had been smeared over with juice of raspberries, and this even to the fingers ends; and the skin appeared inflamed and swollen, as it were; the arms, hands, and fingers, were often evidently so, and very stiff, and somewhat painful. This crimson colour of the skin seemed indeed peculiar to this disease. Though the eruption seldom failed of giving some manifest relief to the patient, as to anxiety, sickness at stomach, vomiting, purging, &c. yet there was observed an universal fiery eruption on some persons, without the least abatement of the symptoms, nay almost every symptom seemed more aggravated, particularly the fever, load at breast, anxiety, and delirium; Dr Huxham knew more than one or two patients die in the most raging phrensy, covered with the most universal fiery rash he ever saw: so that, as in the highly confluent smallpox, it seemed only to denote the quantity of the disease, as he terms it.

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He had under his care a young gentleman, about 12 years of age, whose tongue, fauces, and tonsils, were as black as ink, and he swallowed with extreme difficulty; he continually spit off immense quantities of a black, sanious, and very fetid matter, for at least eight or ten days:—about the seventh day, his fever being somewhat abated, he fell into a bloody dysentery, though the bloody, sanious, fetid expectoration still continued, with a most violent cough. He at length indeed got over it, to the very great surprise of every one that saw him. Now, in this patient, a severe and universal rash broke out upon the second and third day; and the itching of his skin was so intolerable, that he tore it all over his body in a most shocking manner; yet this very great and timely eruption very little relieved his fever and phrensy, or prevented the other dreadful symptoms mentioned.

An early and kindly eruption, however, was most commonly a very good omen; and, when succeeded by a very copious desquamation of the cuticle, one of the most favourable symptoms that occurred: but when the eruption turned of a dusky or livid colour, or prematurely or suddenly receded, every symptom grew worse, and the utmost danger impended, especially if purple or black spots appeared up and down, as sometimes happened; the urine grew limpid, and convulsions came on, or a fatal suffocation soon closed the tragedy.

The disease was generally at the height about the fifth or sixth day in young persons, in the elder not so soon; and the crisis many times was not till the 11th or 12th, and then very imperfect; some adults however, were carried off in two or three days; the distemper either falling on the lungs, and killing in a peripneumonic manner; or on the brain, in which case the patient either died raving or comatose. In some, the disease brought on a very troublesome cough, purulent expectoration, hæmoptoë, and hectic fever; in which they lingered on for several weeks, and then died tabid.

If a gentle easy sweat took place on the third or fourth day; if the pulse became more slow, firm, and equal; if the sloughs of the fauces cast off in a kindly manner, and appeared at the bottom tolerably clean and florid; if the breathing was more soft and free, and some degree of vigour and quickness returned in the eyes; all was well, and a salutary crisis followed soon by a continuance of the sweat, and a turbid, subsiding, farinaceous urine, a plentiful expectoration, and a very large desquamation of the cuticle. But if a rigor came on, and the exanthemata suddenly disappeared or turned livid;

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livid; if the pulse grew very small and quick, and the skin remained hot and parched as it were, the breathing more difficult, the eyes dead and glassy, the urine pale and limpid, a phrensy or coma succeeded, with a coldish clammy sweat on the face or extremities; life was despaired of, especially if a singultus and choaking or gulping in the throat attended, with sudden, liquid, involuntary, livid stools, intolerably fetid. In some few patients, Dr Huxham observed, some time before the fatal period, not only the face bloated, sallow, shining and greasy as it were, but the whole neck very much swollen, and of a cadaverous look; and even the whole body became in some degree œdematous; and the impression of a finger would remain fixed in a part, the skin not rising again as usual; an indication that the blood stagnated in the capillaries, and that the elasticity of the fibres was quite lost.

Medical writers are still much divided in opinion, whether the cynanche maligna is to be considered as the same disease with the scarlatina anginosa, afterwards to be treated of, or not. This question will afterwards come to be more fully discussed. At present we may only observe, that although ulcerous sore throats of a malignant nature often appear sporadically, yet that the disease above described appears only as an epidemic, and is always the consequence of contagion.

We have, therefore, no doubt that the cynanche maligna of Huxham, Fothergill, and Cullen, is precisely the same disease with the scarlatina anginosa of Sauvage, Withering, and other late writers. This is abundantly demonstrated by the diversities which take place in the appearance of the disease among children of the same family during the same epidemic.

Prognosis. This may be easily gathered from the above description. The malignant and putrid tendency of the disease is evident, and an increase of the symptoms which arise from that putrescent disposition of the body must give an unfavourable prognostic. On the contrary, a decrease of these, and an apparent increase of the *vis vitæ*, are favourable: in general, what is observed to be favourable in the nervous and putrid malignant fevers, is also favourable in this, and *vice versa*.

Causes. Since the accurate accounts given by Dr Fothergill and Huxham of the epidemics which prevailed about 50 years ago, this disease has frequently been observed at times epidemic in almost every different part of Britain. Like smallpox, measles, and chincough, it seems in every case to be the effect of a peculiar and specific contagion. It has been observed to prevail, equally generally in every situation, and at every season; and on exposure to the contagion, no age, sex, or condition, is exempted from it. But the having once had the disease, seems in this affection to afford the same security against future contagion as in the smallpox: at least instances, where it can be said that the same individual has been twice affected with it, are both very rare and very doubtful, as well as in smallpox.

Cure. Like other febrile contagions, the malignant ulcerous sore throat is terminated only by a natural course; and the chief business of the practitioner is to combat unfavourable occurrences. In this the septic tendency of the disease is chiefly to be kept in view. The debility with which it is attended renders all evacuations by bleeding and purging improper, except in a few instances where the debility is less, and the inflammatory symptoms more considerable. The fauces are to be preserved from the effects of the acrid matter poured out upon them, and are therefore to be frequently washed out by antiseptic gargles or injections; and the putrescent state of the whole system should be guarded against and corrected by internal antiseptics, especially by the Peruvian bark given in the beginning and continued through the course of the disease. Great benefit is also often derived from the liberal use of the mineral acids. Both the sulphuric and muriatic, in a state of proper dilution, have been highly extolled by different medical writers, and are productive of the best effects in actual practice, when they can be introduced to a sufficient extent. In particular, the oxygenated muriatic acid, as recommended by Mr Braithwaite, has been found productive of the greatest advantages. Emetics, both by vomiting and nauseating, prove useful. When any considerable tumor occurs, blisters applied externally will be of service, and in any case may be proper to moderate the inflammation.

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Very lately, the internal use of the capsicum annuum, or Cayenne pepper, as it is commonly called, has been highly celebrated in this affection; and it is particularly said to have been employed with singular success in the West Indies.

But of all the remedies lately proposed, none has been more highly extolled than the external use of cold water. It has even been contended by some that by dashing cold water on the surface of the body, an immediate artificial cure of this disease may be obtained. We are, however, fully persuaded, that cold water will no more destroy the contagion of this disease than of smallpox; and we cannot help thinking that the practice is seldom necessary, and sometimes hurtful.

Sp. III. Cynanche trachealis. 179

The Croup.

Cynanche trachealis, *Sauv.* sp. 5.
Cynanche laryngea auctorum, *Eller* de cogn. et curand. morb. sect. 7.
Anginæ inflammatoriæ, sp. 1. *Boerh.* 801.
Angina latens et difficilis, *Dodon.* obs. 18.
Angina interna, *Tulp.* l. 1. obs. 51.
Angina perniciosa, *Greg. Horst.* Obs. l. iii. obs. 1.
Suffocatio stridula, *Home* on the Croup.
Asthma infantum, *Millar* on the Asthma and Chincough.
Asthma infantum spasmodicum, *Rush*, Dissertation, Lond. 1770.
Cynanche stridula, *Crawford* Dissert. Inaug. Edin. 1771.
Angina epidemica anno 1743. *Molloy* apud *Rutty's* History of the weather.
Morbus strangulatorius, *Starr*, Phil. Trans. N° 495.
Morbus truculentus infantum, *Francof.* ad Viadrum et in vicinia grassans ann. 1758. C. à Bergen. A nova. N. C. tom. ii. p. 157.
Catarrhus suffocativus Barbadensis ann. 1758. *Hillary's* Diseases of Barbadoes.

Angina

Phlegmasiæ. Cynanche.

Angina inflammatoria infantum, *Russel*, Oecon. nat. p. 70.

Angina polyposa sive membranacea *Michealis*. Argentorati 1778, et auctores ab eo allegati.

The best description of this disease we have in Dr Cullen's Practice of Physic. He informs us, that it consists in an inflammation of the glottis, larynx, or upper part of the trachea, whether it affect the membranes of these parts or the muscles adjoining. It may arise first in these parts, and continue to subsist in them alone; or it may come to affect these parts from the cynanche tonsillaris, or maligna, spreading into them.

In either way it has been a rare occurrence, and few instances of it have been marked and recorded by physicians. It is to be known by a peculiar croaking sound of the voice, by difficult respiration, with a sense of straitening about the larynx, and by a pyrexia attending it.

From the nature of these symptoms, and from the dissection of the bodies of persons who died of this disease, there is no doubt of its being of an inflammatory kind. It does not, however, always run the course of inflammatory affections; but frequently produces such an obstruction of the passage of the air, as suffocates, and thereby proves suddenly fatal.

It particularly proves fatal, in consequence of the trachea being obstructed by a membranous substance lining the inside of it, and very nearly approaching in appearance to the inflammatory exudation often discovered on the intestinal canal in those dying of enteritis.

If we judge rightly of the nature of this disease, it will be obvious, that the cure of it requires the most powerful remedies of inflammation to be employed upon the very first appearance of the symptoms. When a suffocation is threatened, whether any remedies can be employed to prevent it, is not yet determined by sufficient experience: but it is evident, that in certain cases the life of the patient can be preserved only by the removal of that matter which obstructs the passage of air through the trachea.

The accounts which books have hitherto given us of inflammations of the larynx, and the parts connected with it, amount to what we have now said; and many instances are recorded of the disease happening in adult persons: but there is a peculiar affection of this kind happening to infants. which has been little taken notice of till lately. Dr Francis Home is the first who has given any distinct account of this disease; but, since he wrote, several other authors have taken notice of it, and have given different opinions concerning it.

This disease seldom attacks infants till after they have been weaned. After this period, the younger they are, the more liable they are to the disease. The frequency of it becomes less as children become more advanced; and there are few instances of children above 12 years of age being affected with it. It attacks children of the midland countries, as well as those who live near the sea; but it occurs much more frequently at certain places than at others. It does not appear to be contagious; and its attacks are frequently repeated in the same child. It is often manifestly the effect of cold applied to the body; and therefore appears most frequently in the winter and spring seasons. It very commonly comes on with the ordinary symptoms of a catarrh; but sometimes the peculiar symptoms of the disease show themselves at the very first.

These peculiar symptoms are the following: A hoarseness, with some shrillness and ringing sound, both in speaking and coughing, as if the noise came from a brazen tube. At the same time, there is a sense of pain about the larynx, some difficulty of respiration, with a whizzing sound in inspiration, as if the passage of the air were straitened. The cough which attends it, is commonly dry; and if any thing be spit up, it is matter of a purulent appearance, and sometimes films resembling portions of a membrane. With all these symptoms, there is a frequency of pulse, a restlessness, and an uneasy sense of heat. When the internal fauces are viewed, they are sometimes without any appearance of inflammation; but frequently a redness, and even swelling, appears; and sometimes there is an appearance of matter like to that rejected by coughing, together with the symptoms now described, and particularly with great difficulty of breathing, and a sense of strangling in the fauces, by which the patient is sometimes suddenly taken off.

Many dissections have been made of infants who had died of this disease, and almost constantly there has appeared a preternatural substance, apparently membranous, lining the whole internal surface of the upper part of the trachea, and extending in the same manner downwards into some of its ramifications. This preternatural membrane may be easily separated, and sometimes has been found separated in part from the subjacent proper membrane of the trachea. This last is commonly found entire, that is, without any appearance of erosion or ulceration; but it frequently shows the vestiges of inflammation, and is covered by a matter resembling pus, like to that rejected by coughing; and very often a matter of the same kind is found in the bronchiæ, sometimes in considerable quantity.

From the remote causes of this disease; from the catarrhal symptoms commonly attending it; from the pyrexia constantly present with it; from the same kind of preternatural membrane being found in the trachea when the cynanche maligna is communicated to it; and from the vestiges of inflammation on the trachea discovered upon dissection; we must conclude, that this disease consists in an inflammatory affection of the mucous membrane of the larynx and trachea, producing an exudation analogous to that found on the surface of inflamed viscera, and appearing partly in a membranous crust, and partly in a fluid form resembling pus.

Though this disease consists in an inflammatory affection, it does not commonly end either in suppuration or gangrene. The most troublesome circumstance of it seems to consist in a spasm of the muscles of the glottis, threatening suffocation.

When this disease terminates in health, it is by resolution of the inflammation, by ceasing of the spasm of the glottis, by an expectoration of the matter exuding from the trachea, and of the crusts formed there,

there, and frequently it ends without any expectoration, or at least with such only as attends an ordinary catarrh. But in some instances, a salutary termination has very speedily taken place, in consequence of the discharge of the membranous substance from the trachea, even under its proper tubular form.

When the disease ends fatally, it is by a suffocation seemingly depending upon a spasm affecting the glottis; but sometimes, probably, depending on a quantity of matter filling the bronchiæ or obstructing the trachea.

As we suppose the disease to be an inflammatory affection, so we attempt the cure of it by the usual remedies of inflammation. Bleeding, both general and topical, has often given immediate relief, and, by being repeated, has entirely cured the disease. Blistering also, near the part affected, has been found useful. Upon the first attack of the disease, vomiting, immediately after bleeding, seems to be of considerable use, and sometimes suddenly removes the disease. But emetics are still more useful in advanced periods. By the employment of these, the matter obstructing the trachea, and inducing spasmodic affections, has often been successfully removed, when the situation of the patient seemed to be almost desperate. And as in the progress of the disease fresh effusions of this matter are very apt to take place, the frequent repetition of emetics becomes necessary. It is often necessary to have recourse to those operating the most expeditiously, such as sulphate of zinc even in large doses. In every stage of the disease, the antiphlogistic regimen is necessary, and particularly the frequent use of laxative glysters. Some practitioners consider mercury, particularly under the form of calomel, as an almost infallible remedy in this disease. It has particularly been extolled by Mr James Anderson, an eminent surgeon in Edinburgh. But we are sorry to say that in some cases at least, after the fairest trial, it has been found to fail. Though we suppose that a spasm affecting the glottis is often fatal in this disease, antispasmodic medicines have not in general been found of great service. Some, however, have strongly recommended the use of asafœtida under the form of injection; others place great confidence in oil or oily mixtures, taken by the mouth; but more immediate benefit is derived from tepid bathing, and the employment of sulphuric ether, both externally and internally.

By these, when the disease is spasmodic, it is often successfully removed. But by much the most dangerous form of the disease is the inflammatory state giving the exudation. And when this inflammatory exudation has even been removed from the upper part of the trachea, yet it has sometimes proved fatal from the inflammation and exudation extending to the branches of the aspera arteria. By such an occurrence the writer of the present article had the misfortune to lose a favourite son; an amiable youth, in the fourteenth year of his age, who was highly admired and sincerely regretted by all to whom he was known.

180 Sp. IV. Cynanche pharyngéa.

Cynanche pharyngea, *Sauv.* sp. 6. *Eller* de cogn. et cur. sect. 7.

Anginæ inflammatoriæ, sp. 4. *Boerh.* 804.

This is not materially different from the cynanche tonsillaris; only that the inflammation is said to begin in the pharynx, though Dr Cullen says he never knew an instance of it. The symptoms are almost the same, and the cure is precisely so, with that of the cynanche tonsillaris.

Sp. V. Cynanche parotidæa. 181

Cynanche parotidæa, *Sauv.* sp. 14. *Gallis* Oreillons et Ourles, *Tissot* Avis au peuple, N° 116. *Encyclopédie*, au mot *Oreillons*.

Angina externa, *Anglis* the Mumps, *Russel* œcon. natur. p. 114. *Scotis* the Branks.

Catarrhus Bellinsulanus, *Sauv.* sp. 4. Osservazioni di *Girol. Gaspari*, Venez. 1731. Osservazioni di *Larg. Tozetti*, Racolta 1ma, p. 176.

This is a disease well known to the vulgar, but little taken notice of by medical writers. It is often epidemic, and manifestly contagious. It comes on with the usual symptoms of pyrexia, which is soon after attended with a considerable tumour of the external fauces and neck. The swelling appears first as a glandular moveable tumor at the corner of the lower jaw; but it soon becomes uniformly diffused over a great part of the neck, sometimes on one side only, but more commonly on both. The swelling continues to increase till the fourth day; but from that period it declines, and in a few days more goes off entirely. As the swelling of the fauces recedes, it not unfrequently happens that some tumor affects the testicles in the male sex, or the breasts in the female. These tumors are sometimes large, hard, and somewhat painful; but are seldom either very painful or of long continuance. The pyrexia attending this disease is commonly slight, and goes off with the swelling of the fauces; but sometimes, when the swelling of the testicles does not succeed to that of the fauces, or when the one or the other has been suddenly repressed, the pyrexia becomes more considerable, is often attended with delirium, and has sometimes proved fatal.

As this disease commonly runs its course without either dangerous or troublesome symptoms, so it hardly requires any remedies. An antiphlogistic regimen, and avoiding cold, are all that will be commonly necessary. But when, upon the receding of the swellings, the pyrexia comes to be considerable, and threatens an affection of the brain, it will be proper, by warm fomentations, to bring back the swelling; and by vomiting, bleeding, or blistering, to obviate the consequences of its absence.

Genus XI. PNEUMONIA. 182

Febris pneumonica, *Hoffm.* II. 136.

Sp. I. Peripneumonia. 183

Peripneumony, or Inflammation of the Lungs.

Peripneumonia, *Sauv.* gen. 112. *Lin.* 34. *Vog.* 51. *Sag.* gen. 311. *Boerh.* 820. *Juncker* 67.

Peripneumonia pura sive vera Auctorum, *Sauv.* sp. 1.

Peripneumonia gastrica, *Sauv.* sp. 11. *Morgagn.* de caus. et sed. Epist. xx. art. 30, 31.

Peripneumonia catarrhalis, *Sauv.* sp. 6.

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Peripneumonia notha, *Sydenh.* sect. 6. cap. 4. *Boerh.* 867. *Morgagni* de caus. et sed. Epist. xxi. 11.—15.
Peripneumonia putrida, *Sauv.* sp. 2.
Peripneumonia ardens, *Sauv.* sp. 3.
Peripneumonia maligna, *Sauv.* sp. 4.
Peripneumonia typhodes, *Sauv.* sp. 5.
Amphimerina peripneumonica, *Sauv.* sp. 15.

Sp. II. Pleuritis.

The *Pleurisy*, or Inflammation of the Pleura.

Pleuritis, *Sauv.* gen. 103. *Lin.* 27. *Vog.* 56. *Sag.* gen. 303. *Boerh.* 875. *Junck.* 67.
Paraphrenesis, *Sauv.* gen. 102. *Lin.* 26.
Paraphrenitis, *Vog.* 55. *Boerh.* 907.
Diaphragmitis, *Sag.* gen. 304.
Pleuritis vera, *Sauv.* sp. 1. *Boerh.* 875. *Verna* princeps morb. acut. pleuritis, l. 1. cap. 2. 3. *Zeviani* della parapleuritide, cap. 3. *Morgagni* de sed. et caus. morb. Epist. xx. art. 56. xxi. 45. *Wendt* de pleuritide, apud *Sandifort*, thes. ii.
Pleuritis pulmonis, *Sauv.* sp. 2. *Zevian.* dell. parapleur. iii. 28, &c.
Pleuropneumonia, pleuro-peripneumonia, peripneumo-pleuritis Auctorum. *Baronius* de pleuri-pneumonia. Ill. *Halleri* opuscul. patholog. obs. 13. *Morgagni* de sed. et caus. Epist. xx. & xxi. passim. *Cleghorn*, Minorca, p. 247. *Triller* de pleuritide, aph. 1, 2, 3. cap. i. 8. *Huxham*, Dissert. on pleurisies, &c. chap. i. Ill. *Pringle*, Dis. of the army.
Pleuritis convulsiva, *Sauv.* sp. 13. *Bianch.* Hist. hep. vol. i. p. 234.
Pleuritis hydrothoracica, *Sauv.* sp. 15. *Morgagni* de caus. et sed. xx. 34.
Pleuritis dorsalis, *Sauv.* sp. 3. *Verna*, p. 3. cap. 8.
Pleuritis mediastini, *Sauv.* sp. 3. *P. Sal. Div.* de affec. part. cap. 6. *Freind*, Hist. Med. de Avenzoare.
Mediastina, *Vog.* 52.
Pleuritis pericardii, *Sauv.* sp. 5. *Verna*, p. iii. cap. 9.
Parapleuritis, *Zeviani* della parapleuritide.
Pleurodyne parapleuritis, *Sauv.* sp. 19.
Paraphrenesis diaphragmatica, *Sauv.* sp. 1. *De Haen.* Rat. med. i. 7. iii. p. 31.
Paraphrenesis pleuritica, *Sauv.* sp. 2.
Paraphrenesis hepatica, *Sauv.* sp. 3.

Under the general head of *Pneumonia*, Dr Cullen comprehends all inflammations of the thoracic viscera, or membrane lining the inside of that cavity; as the symptoms do not always sufficiently distinguish the seat of the affection, nor does a difference in the situation of the affected place make any difference in the cure.

Description. Pneumonic inflammation, however various in the seat, always discovers itself by pyrexia, difficult breathing, cough, and pain in some part of the thorax. It almost always comes on with a cold stage, and is accompanied with the other symptoms of pyrexia; though in some few instances the pulse may not be more frequent, nor the heat of the body increased beyond what is natural. Sometimes the pyrexia is from the beginning accompanied with the other symptoms; but frequently it is formed some hours before them, and particularly before the pain be felt. The pulse for the most part is frequent, full, strong, hard, and quick; but, in a few instances, especially in the advanced state of the disease, it is weak, soft, and at the same time irregular. The difficulty of breathing is most considerable in inspiration, both because the lungs do not easily admit of a full dilatation, and because the dilatation increases the pain attending the disease. The difficulty of breathing is also greater when the patient is in one posture of the body rather than another. It is generally greater when he lies on the side affected; though sometimes the contrary happens. Very often the patient cannot lie upon either side, and can find ease only when lying on the back; and sometimes he cannot breathe readily, except when in somewhat of an erect posture. The cough, in different cases, is more or less urgent or painful. It is sometimes dry, or without any expectoration, especially in the beginning of the disease; but more commonly it is, even from the beginning, moist, and the matter spit up various both in consistence and colour, and frequently it is streaked with blood. The pain is also different in different cases, and felt in different parts of the thorax, but most frequently in one side. It has been said to affect the right side more frequently than the left; but this is uncertain, and we are sure that the left side has been very often affected. Sometimes it is felt as if it was under the sternum; sometimes in the back between the shoulders; and when in the sides, its place has been higher or lower, more forward or backward; but the place of all most frequently affected is about the sixth or seventh rib, near the middle of its length, or a little more forward. The pain is often severe and pungent; but sometimes more dull and obtuse, with a sense of weight rather than of pain. It is most especially severe and pungent when occupying the place last mentioned. For the most part it continues fixed in one part, but sometimes shoots from the side to the scapula on one hand, or to the sternum and clavicle on the other.

Dr Cullen supposes that the disease is always seated, or at least begins, in some part of the pleura, taking that membrane in its greatest extent, as now commonly understood; that is, as covering not only the internal surface of the cavity of the thorax, but also as forming the mediastinum, and as extended over the pericardium, and over the whole surface of the lungs. But as the symptoms never clearly indicate where the seat of the disease is, there is but little foundation for the different names by which it has been distinguished. The term *pleurisy* is improperly limited to that inflammation which begins in and chiefly affects the pleura costalis. This Dr Cullen thinks is a rare occurrence; and that the pneumonia much more frequently begins in the pleura investing the lungs, producing all the symptoms which belong to what hath been called the *pleuritis vera*. The word *peripneumony* has been applied to an inflammation beginning in the parenchyma, or cellular texture of the lungs, and having its seat chiefly there. But to Dr Cullen it seems very doubtful if any acute inflammation of the lungs, or any disease which has been called *peripneumony*, be of that kind. It seems probable, that

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that every acute inflammation begins in membranous parts; and in every dissection of persons who have died of peripneumony, the external membrane of the lungs, or some part of the pleura, has appeared to have been considerably affected. An inflammation of the pleura covering the upper surface of the diaphragm, has been distinguished by the appellation of *paraphrenitis*, as supposed to be attended with the peculiar symptoms of delirium, *risus sardonicus*, and other convulsive motions: but it is certain, that an inflammation of that portion of the pleura, and affecting also even the muscular substance of the diaphragm, has often taken place without any of the symptoms above mentioned; and neither the dissections which have fallen under Dr Cullen's observation, nor any accounts of dissections, support the opinion that an inflammation of the pleura covering the diaphragm is attended with delirium more commonly than any other pneumonic inflammation.—It is to be observed, however, that though the inflammation may begin in one particular part of the pleura, the morbid affection is commonly communicated to the whole extent of the membrane.

The pneumonic inflammation, like others, may terminate by resolution, suppuration, or gangrene: but it has also a termination peculiar to itself; namely, when it is attended with an effusion of blood into the cellular texture of the lungs, which, soon interrupting the circulation of the blood through the viscus, produces a fatal suffocation. This indeed appears to be the most common termination of pneumonic inflammation when it ends fatally; for upon the dissection of almost every person who has died of this disease, it appears that such an effusion had happened. From the same dissections we learn, that pneumonic inflammation commonly produces an exudation from the internal surface of the pleura, which appears partly as a soft viscid crust, often of a compact membranous form, covering every where the surface of the pleura, and particularly those parts where the lungs adhere to the pleura costalis, or mediastinum; and this crust seems always to be the cement of such adhesion. The same exudation shows itself also by a quantity of a serous fluid commonly found in the cavity of the thorax; and some exudation or effusion is usually found to have been made into the cavity of the pericardium. It seems likewise probable, that an effusion of this kind is sometimes made into the cavity of the bronchiæ; for in some persons who have died after labouring under a pneumonic inflammation for a few days only, the bronchiæ have been found filled with a considerable quantity of serous and thickish fluid, which must be considered rather as the effusion above mentioned, having had its thinner parts taken off by respiration, than as a pus so suddenly formed in the inflamed part. It is, however, not improbable, that this effusion, as well as that made into the cavities of the thorax and pericardium, may be a matter of the same kind with that which in other inflammations is poured into the cellular texture of the parts inflamed, and there converted into pus; but in the thorax and pericardium it does not always put on this appearance, because the crust covering the surface prevents the absorption of the thinner part. This absorption, however, may be compensated in the bronchiæ, by the drying power of the air; and therefore the effusion into them may assume a more purulent appearance. In many cases of pneumonic inflammation, when the expectoration is very copious, it is difficult to suppose that the whole proceeds from the mucous follicles of the bronchiæ; and it seems probable that a great part of it may come from the effused serous fluid just mentioned; and this too will account for the appearance of the expectoration being so often purulent. Perhaps the same thing will account for that purulent matter found in the bronchiæ, which Mr de Haen says he had often observed when there was no ulceration in the lungs, and which he accounts for in a very strange manner, namely, by supposing a pus formed in the circulating blood.

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Dr Cullen is of opinion, that the effusion into the bronchiæ above mentioned often concurs with the effusion of red blood into the cellular substance of the lungs to occasion the fatal suffocation which frequently terminates peripneumony: that the effusion of serum alone may have this effect: and that the serum poured out in a certain quantity, rather than any debility in the powers of expectoration, is the cause of that cessation of spitting which precedes the fatal event; for in many cases the expectoration has ceased, when no other symptoms of debility have appeared, and when, upon dissection, the bronchiæ have been full of liquid matter. Nay, it is even probable, that in some cases such an effusion may take place without any symptoms of violent inflammation; and in other cases the effusion taking place may seem to remove the symptoms of inflammation which had appeared before, and thus account for those unexpected fatal terminations which have sometimes happened.

Pneumonic inflammation seldom terminates by resolution, without being attended with some evident evacuation. An hæmorrhagy from the nose happening on some of the first days of the disease has sometimes put an end to it; and it is said, that an evacuation from the hæmorrhoidal veins, a bilious evacuation by stool, and an evacuation of urine with a copious sediment, have severally had the same effect; but such occurrences have been rare. The evacuation most frequently attending, and seeming to have the greatest effect in promoting resolution, is an expectoration of a thick, white, or yellowish matter, a little streaked with blood, copious, and brought up without much or violent coughing. Very frequently the resolution of this disease is attended with, and perhaps produced by, a sweat, if it be warm, fluid, copious, over the whole body, and attended with an abatement of the frequency of the pulse, heat of the body, and other febrile symptoms. Although, from the history now given, it appears that pleurisy and peripneumony cannot with propriety be considered as different diseases, yet it is certain that in different cases this affection occurs with an assemblage of symptoms separate and distinct. Thus even Dr Cullen himself, in his Nosology, has defined pleuritis to consist in pyrexia, attended with pungent pain of the side, painful respiration, difficulty of lying down, particularly on the affected side, and distressing cough, in the beginning dry, but afterwards humid, and often with bloody expectoration. While again he has defined peripneumony to consist in pyrexia, attended with a dull pain under the sternum and between the shoulders, anxiety, difficulty of breathing, humid

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mid cough, expectoration generally bloody, a soft pulse, and a tumid livid appearance of the countenance. It is highly probable, that the first of these sets of symptoms chiefly arises from a state of active inflammation, and the second from effusion. Thus, in certain cases, the symptoms may appear perfectly separate and distinct; but more frequently both inflammation and effusion are united; and thus the symptoms in both definitions are in general combined in the same patient. But still pleuritis, strictly so called, may be considered as characterized by the acute pungent pain at a particular spot of the chest, and that pain much aggravated on a full inspiration; while proper peripneumonia is distinguished by the dull gravative pain extended over the whole chest, and by the laborious respiration.

Causes of, and persons subject to, this disorder. The remote cause of pneumonic inflammation is commonly cold applied to the body, obstructing perspiration, and determining to the lungs, while at the same time the lungs themselves are exposed to the action of cold. These circumstances operate chiefly when an inflammatory diathesis prevails in the system; and therefore those principally affected with this disease are persons of the greatest vigour, in cold climates, often in the winter season, but particularly in the spring, when vicissitudes of heat and cold are frequent. The disease, however, may arise in any season when such varieties take place. Other remote causes also may have a share in producing this distemper; such as every means of obstructing, straining, or otherwise injuring, the pulmonary organs. The pneumatic inflammation has sometimes been so much an epidemic, that it hath been suspected of depending on a specific contagion; but Dr Cullen never met with an instance of its being contagious.

Prognosis. In pneumatic inflammations, a violent pyrexia is always dangerous. The danger, however, is chiefly denoted by the difficulty of breathing. When the patient can lie on one side only; when he can lie on neither side, but only on his back; when he cannot breathe with tolerable ease, except when the trunk of his body is erect; when even in this posture the breathing is very difficult, and attended with a turgescence and flushing of the face, with partial sweats about the head and neck, and an irregular pulse; these circumstances mark the difficulty of breathing in different degrees; and consequently, in proportion, the danger of the disease. A frequent violent cough, aggravating the pain, is always the symptom of an obstinate disease; and as the disease is seldom or never resolved without some expectoration, so a dry cough must always be an unfavourable symptom.

The proper characteristics of the expectoration have been already laid down; and though an expectoration which has not these marks must indicate a doubtful state of the disease, yet the colour alone can give no certain prognostic. An acute pain, very much interrupting inspiration, is always the mark of a violent disease; but not of a more dangerous disease than an obtuse pain, attended with very difficult respiration, demonstrating effusion into the cells.

When the pains, which had at first affected one side only, shall afterwards spread into the other; or when, leaving the side first affected, they pass entirely into the other; these are always marks of a dangerous disease. A delirium coming on during a pneumonic inflammation is always a symptom denoting much danger.

When pneumonic disorders terminate fatally, it is on one or other of the days of the first week, from the third to the seventh. This is the most common case; but, in a few instances, death has happened at a later period. When the disease is violent, but admitting of resolution, this also happens frequently in the course of the first week; but in a more moderate disease the resolution is often put off to the second week. The disease generally suffers a remission on some of the days; from the third to the seventh: which, however, may be often fallacious, as it sometimes returns again with as much violence as before: and in such a case with great danger. Sometimes it disappears on the third day, while an erysipelas makes its appearance on some external part; and if this continue fixed, the pneumatic inflammation does not recur. If the disease continue beyond the 14th day, it will terminate in a suppuration, or PHTHISIS. The termination by gangrene is much more rare than has been imagined: and when it does occur, it is usually joined with the termination by effusion; the symptoms of the one being hardly distinguishable from those of the other.

Cure. This must proceed upon the general plan mentioned under SYNOCHA; but, on account of the importance of the part affected, the remedies must be employed early, and as fully as possible: and these are chiefly directed with one of three views, viz. for obtaining a resolution of the inflammation in the thorax, for mitigating the urgent symptoms before a resolution can be effected, and for counteracting or obviating the consequences of the disease. Venesection is the remedy chiefly to be depended on; and may be performed in either arm, as the surgeon finds most convenient; and the quantity taken away ought in general to be as large as the patient's strength will allow. The remission of pain, and the relief of respiration, during the flowing of the blood, may limit the quantity to be then drawn: but if these symptoms of relief do not appear, the bleeding should be continued to a considerable extent, unless symptoms of a beginning syncope come on. It is seldom that one bleeding, however large, will cure this disease; and though the pain and difficulty of breathing may be much relieved by the first bleeding, these symptoms commonly and after no long interval recur, often with as much violence as before. In this case the bleeding is to be repeated even on the same day, and perhaps to the same quantity as before. Sometimes the second bleeding may be larger than the first. There are persons, who, by their constitution, are ready to faint even upon a small bleeding; and in such persons this may prevent the drawing so much blood at first as a pneumonic inflammation may require: but as the same persons are found to bear after-bleedings better than the first, this allows the second and subsequent bleedings to be larger, and to such a quantity as the symptoms of the disease may seem to require.

Bleedings are to be repeated according to the state of the symptoms, and they will be more effectual when practised in the course of the first three days than afterwards; but they are not to be omitted though four days of the disease may already have elapsed. If the physician has not been called in time, or the first bleed-

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With respect to the quantity of blood which may be taken away with safety, no general rules can be given; as it must be very different according to the state of the disease, and the constitution of the patient. In an adult male of tolerable strength, a pound of blood is a full bleeding. Any quantity above 20 ounces is a large, and any quantity below 12 is a small, bleeding. An evacuation of four or five pounds, in the course of two or three days, is generally as much as most patients will bear; but if the intervals between the bleedings, and the whole of the time during which the bleedings have been employed, have been long, the quantity taken upon the whole may be greater.

When a large quantity of blood has been taken from the arm, and it is doubtful if more can be taken in that manner with safety, some blood may still be taken by cupping and scarifying. This will especially be proper, when the recurrence of the pain, rather than the difficulty of breathing, becomes the urgent symptom; and then the cupping and scarification should be made as near as possible to the pained part.

An expectoration sometimes takes place very early in this disease; but if the symptoms continue urgent, the bleedings must be repeated notwithstanding the expectoration: but in a more advanced state, and when the symptoms have suffered a considerable remission, we may then trust the cure to the expectoration alone. It is not observed that bleeding, during the first days of the disease, stops expectoration; on the contrary, it has been often found to promote it; and it is only in a more advanced state of the disease, when the patient has been already exhausted by large evacuations and a continuance of his illness, that bleeding seems to put a stop to expectoration; and even then, this stoppage seems not to take place so much from the powers of expectoration being weakened by bleeding, as by its favouring the serous effusion in the bronchiæ, already taken notice of.

Besides bleeding, every part of the antiphlogistic regimen ought here to be carefully employed; the patient must keep out of bed as much as he can bear; must have plenty of warm diluting drinks, impregnated with vegetable acids, accompanied with nitre or some other cooling neutral salt; and the belly also ought to be kept open by emollient clysters or cooling laxative medicines. Vomiting in the beginning is dangerous; but in a somewhat advanced state of the disease emetics have been found the best means of promoting expectoration. Fomentations and poultices to the pained part have been found useful; but blistering is found to be much more effectual. A blister, however, ought not to be applied till at least one bleeding has been premised, as venesection is less effectual when the irritation of a blister is present. If the disease be moderate, a blister may be applied immediately after the first bleeding; but in violent cases, where it may be presumed that a second bleeding may soon be necessary after the first, it will be proper to delay the blister till after the second bleeding, when it may be supposed that the irritation occasioned by the blister will be over before another bleeding becomes necessary. It may frequently be of use in this disease to repeat the blistering; and in that case the plasters should always be applied somewhere on the thorax, for when applied to more distant parts they have less effect. The keeping the blistered parts open, and making what is called a *perpetual blister*, has much less effect than a repeated blistering.

Pneumonia. Many methods have been proposed for promoting expectoration, but none appear to be sufficiently effectual; and some of the expectorants, being acrid stimulant substances, are not very safe. The gums usually employed seem to be too heating; the squills less so; but they are not very powerful, and sometimes inconvenient, by the constant nausea they occasion. The volatile alkali may be of service as an expectorant, but it ought to be reserved for an advanced state of the disease. Mucilaginous and oily demulcents appear to be useful, by allaying that acrimony of the mucus which occasions too frequent coughing; and which coughing prevents the stagnation and thickening of the mucus, and thereby its becoming mild. The receiving into the lungs the steams of warm water, impregnated with vinegar, has often proved useful in promoting expectoration; and, for this purpose, the machine called the INHALER, lately invented by Dr Mudge of Plymouth, promises to be of great service. But of all others, the antimonial emetics, given in nauseating doses, are perhaps the most powerful for promoting expectoration. The kermes mineral has been greatly recommended; but does not seem to be more efficacious than tartrite of antimony or antimonial wine; and the dose of the kermes is much more uncertain than that of the others.

Though this disease often terminates by a spontaneous sweating, this evacuation ought not to be excited by art, unless with much caution. When, after some remission of the symptoms, spontaneous sweats arise, they may be encouraged; but it ought to be without much heat, and without stimulant medicines. If, however, the sweats be partial and clammy only, and a great difficulty of breathing still remain, it will be very dangerous to encourage them.

Physicians have differed much with regard to the use of opiates in pneumonic affections. It appears, however, that in the beginning of the disease, and before bleeding and blistering have produced some remission of the pain, and of the difficulty of breathing, opiates have had a bad tendency, by their increasing the difficulty of breathing and other inflammatory symptoms. But in a more advanced state of the disease, when the difficulty of breathing has abated, and when the urgent symptom is a cough, proving the chief cause of the continuance of pain and want of rest, opiates may be employed with great advantage and safety. The interruption of the expectoration which they seem to occasion, is for a short time only; and they seem often to promote it, as they occasion a stagnation of what was by frequent coughing dissipated insensibly: and therefore give the appearance of what physicians called *concocted matter*.

Opium combined with calomel has of late been highly extolled in this and other inflammatory diseases by Dr Hamilton of Lynn Regis; who has given a full account

Phthisis pulmonalis. count of the success attending his practice with this remedy for the space of 16 years, in the 9th volume of the Edinburgh Medical Commentaries. And since his recommendation, the same remedy has often been employed by others with great benefit.

Vomica, or *Abscess* of the *Lungs*.

5 Vomica, *Boerh*. 835. *Junck*. 35.
Pleurodyne vomica, *Sauv*. sp. 21.

Phthisis sometimes follows pneumonia, though the case is not frequent. The symptoms of it so much resemble ordinary phthisis, that it can most properly be treated of under that head.

Empyema.

7 This is another consequence of a pneumonia terminating unfavourably, and is occasioned by the effusion of a quantity of purulent matter into the cavity of the thorax, producing a lingering and painful disorder, very often incurable.

Description. The first sign of an empyema is a cessation of the pain in the breast, which before was continual: this is followed by a sensation of weight on the diaphragm; and a fluctuation of matter, sometimes making a noise that may be heard by the bystanders: the acute fever is changed into a hectic, with an exacerbation at night: a continual and troublesome dry cough remains. The respiration is exceedingly difficult, because the lungs are prevented by the matter from fully expanding themselves. The patient can lie easily on that side where the matter is effused, but not on the other, because then the weight of the matter on the mediastinum produces uneasiness. The more the hectic heat is augmented, the more is the body emaciated, and its strength decayed. In some there is danger of suffocation when they stoop down, which goes off when they alter that posture of the body; and in some there is a purulent spitting.—These symptoms are accompanied with great anxiety, palpitations of the heart, and faintings. Sometimes the patients have a sensation like a hot vapour ascending from the cavity of the thorax to their mouth. Others, in a more advanced state of the disease, have a putrid taste in the mouth. At the same time, profuse night sweats waste the body, and greatly weaken the patient. The face at first grows red on that side where the matter lies, at last the Hippocratic face comes on, and the eyes become hollow. The pulse is quick, but more frequently intermitting. Sometimes the nails are crooked, and pustules appear on the thorax; and frequently, according to the testimony of Hippocrates, the feet swell, and, on the affected side of the breast, there is an inflation and swelling of the skin.

Causes, &c. An empyema may arise either from the bursting of a vomica of the lungs, or from a suppuration taking place after the inflammatory stage of pneumonia; or sometimes from a suppuration in the case of a quinsy, when the inflammation had extended to the aspera arteria, from whence arises a kind of bloody spittle, and the patients are afflicted with an empyema, unless they die on the 7th day of the disease, according to the observation of Hippocrates. It may arise also from external violence, as wounds of the thorax, &c. blood extravasated, corrupted, or changed into pus. Like the vomica, it is a rare distemper, but may attack all those subject to pneumonia.

Prognosis. Very few recover after an empyema has been once formed, especially if the operation of paracentesis be neglected. After this operation is performed, if a great quantity of bloody fetid pus be discharged, if the fever continue, and if the patient spit up a purulent, pale, frothy, livid, or green matter, with a decay of strength, there is no hope: But when a small quantity of pus, of a white colour, not very fetid, is discharged; when the fever and thirst presently cease, the appetite returns, and fæces of a good consistence are discharged, the strength also returning in some degree; there is then hope of a perfect recovery. If the matter be not dried up in seven weeks time, the disease readily changes to a fistulous ulcer, which is very difficult to cure. An empyema affecting both sides of the thorax is more dangerous than that which affects only one.

Cure. This consists in evacuating the purulent matter contained in the cavity of the thorax, which is best done by the operation of paracentesis of the thorax. See Surgery. Afterwards the ulcer is to be treated with abstergent and consolidating medicines, and the same internal ones are to be given as in a Phthisis.

Genus XIII. CARDITIS. 188

Inflammation of the *Heart*.

Carditis, *Sauv*. gen. 111. *Vog*. 54.
Pericarditis, *Vog*. 53.
Carditis spontanea, *Sauv*. sp. 1. *Senac*. Traité de Cœur, l. iv. c. 7. *Meckel*, Mem. de Berlin, 1756.
Erysipelas pulmonis, *Lomm*. Observ. lib. ii.

Description. This disease is attended with all the symptoms of pneumonia, but in a higher degree; it is besides said to be accompanied with hydrophobic symptoms, fainting, palpitation of the heart, a seeming madness, a sunk and irregular pulse, watery eyes, and a dejected countenance, with a dry and black tongue. On dissection, the heart and pericardium are found very much inflamed, and even ulcerated, with many polypous concretions.

Causes, &c. The same as in the pneumonia.

Prognosis. In the carditis the prognosis is more unfavourable than in the pneumonia; and indeed, unless the disease very quickly terminates, it must prove fatal, on account of the constant and violent motion of the heart, which exasperates the inflammation, and increases all the symptoms.

Cure. Here bleeding is necessary in as great a degree as the patient can possibly bear, together with blistering, and the antiphlogistic regimen likewise carried to a greater height than in the pneumonia; but the general method is the same as in other inflammatory diseases.

Genus XIV. PERITONITIS. 189

Peritonitis.

Inflammation of the *Peritonæum*.

Sp. I. *Inflammation* of the *Peritonæum* properly so called.

Peritonitis, *Vog*. 62. *Lieutad*. Hist. anat. med. lib. i. obs.

Phlegmasiæ.

obs. 3. *Raygerus* apud eund. lib. i. obs. 341. *Morgagn.* de sed. LVII. 20.

190 Sp. II. *Inflammation* of the *Peritonæum* extended over the *Omentum.*

Epiploitis, *Sauv.* gen. 106. *Sag.* 308.
Omentitis, *Vog.* 61.
Omenti inflammatio, *Boerh.* 985. et Ill. *Van Swieten,* Comm. *Stork.* An. Med. I. 132. *Hulme* on the puerperal feveral fever.

191 Sp. III. *Inflammation* of the *Peritonæum* stretched over the *Mesentery.*

Mesenteritis, *Vog.* 60.
Enteritis mesenterica, *Sauv.* sp. 4.

192 Genus XV. GASTRITIS.

Inflammation of the *Stomach.*

193 A. *Gastritis Phlegmonodæa,* or the *genuine Gastritis.*

Gastritis legitima, *Sauv.* sp. 1. *Eller.* de cogn. et cur. morb. sect. xii. *Haller.* obs. 14. hist. 3. *Lieut.* Hist. Anat. Med. lib. i. 74.
Gastritis erysipelatosa, *Sauv.* sp. 4.
Cardialgia inflammatoria, *Sauv.* sp. 13. *Tralles,* de opio, sect. ii. p. 231.

These diseases Dr Cullen has thought proper to consider all under the general head of Gastritis, as there are no certain signs by which they can be distinguished from each other, and the method of cure must be the same in all.

Description. The inflammation of the stomach is attended with great heat and pain in the epigastric region, extreme anxiety, an almost continual and painful hiccough, with a most painful vomiting of every thing taken into the stomach. Sometimes a temporary madness ensues; and there is an instance in the Edinburgh Medical Essays of the disorder being attended with an hydrophobia. The pulse is generally more sunk than in other inflammations, and the fever inclines to the nature of a typhus. The disorder is commonly of the remitting kind, and during the remissions the pulse frequently intermits. During the height of the disease, a mortal phrensy frequently supervenes. The disease terminates on the fourth, seventh, or ninth day, or from the eleventh to the fifteenth; and is more apt to end in a gangrene than pneumonic inflammations, and more frequently in a scirrhus than in an abscess.

Causes, &c. The inflammation of the stomach may arise from any acrid substance taken into it; from a vehement passion, too large draughts of cold liquor, especially when the person is very hot; from a surfeit; a stoppage of perspiration; repulsion of the gout; inflammations of the neighbouring viscera; or from external injuries, such as wounds, contusions, &c.—It affects chiefly those of a plethoric habit and hot bilious constitution.

Prognosis. This disease is always very dangerous, and the prognosis doubtful, which also must always be in proportion to the severity of the symptoms. A cessation of pain, coldness about the præcordia, great debility, with a languid and intermitting pulse, with an abatement of the hiccough, denote a gangrene and speedy death. From the sensibility of the stomach also, and its great connexion with the rest of the system, it must be obvious, that an inflammation of it, by whatever causes produced, may be attended with fatal consequences; particularly, by the great debility it produces, it may prove suddenly fatal, without running through the usual course of inflammations.—Its tendency to admit of resolution may be known by its having arisen from no violent cause, by the moderate state of the symptoms, and by a gradual remission of these symptoms in the course of the first or at most of the second week of the disease. The tendency to gangrene may be suspected from the symptoms continuing with unremitting violence, notwithstanding the use of proper remedies; and a gangrene already begun may be known by the symptoms above mentioned, particularly great debility and sudden cessation of pain. The tendency to suppuration may be known by the symptoms continuing but in a moderate degree for more than one or two weeks, and by a considerable remission of the pain, while a sense of weight and anxiety still remain. When an abscess has been formed, the frequency of the pulse is first abated: but soon after it increases, with frequent cold shivering, and an exacerbation in the afternoon and evening; followed by night sweats, and other symptoms of hectic fever. These at length prove fatal, unless the abscess open into the cavity of the stomach, the pus be evacuated by vomiting, and the ulcer soon healed.

Gastritis.

Cure. It appears from dissections, that the stomach may very often be inflamed when the characteristic marks of it have not appeared; and therefore we are often exposed to much uncertainty in the cure. But when we have sufficient evidence that a state of active inflammation has taken place in the stomach, the principal object to be aimed at is to obtain a resolution. Before, however, this can be accomplished, it will often be necessary to employ measures with the view of obviating urgent symptoms. When the symptoms appear in the manner above described, the cure is to be attempted by large and repeated bleedings employed early in the disease; and from these we are not to be deterred by the weakness of the pulse, for it will commonly become fuller and softer after the operation. A blister ought also to be applied to the region of the stomach; and the cure will be assisted by fomentations of the whole abdomen, and by frequent emollient and laxative clysters. The irritability of the stomach in this disease will admit of no medicines being thrown into it; and if any can be supposed necessary, they must be exhibited in clysters. Diluting drinks may be tried; but they must be of the very mildest kind, and given in very small quantities at a time. Opiates, in whatever manner exhibited, cannot be retained in the stomach during the first days of the disease; but when the violence of the disease shall have abated, and when the pain and vomiting recur at intervals only, opiates given in clysters are frequently employed with advantage; and after bleeding and blisters no remedy is more effectual either in allaying the pain or vomiting. As soon as the stomach will retain any laxative, gentle refrigerant cathartics, taken by the mouth, such as the soda phosphorata, soda tartarisata, or the like, are

are productive of great benefit. A tendency to gangrene in this disease is to be obviated only by the means just now mentioned; but when it does actually supervene, it admits of no remedy. A tendency to suppuration is to be obviated by the same means employed early in the disease. After a certain period it cannot be prevented by any means whatever; and, when actually begun, must be left to nature; the only thing that can be done by art being to avoid all irritation.

B. *Gastritis Erysipelatosa*, or the *Erysipelatous Gastritis.*

Description. This species of inflammation takes place in the stomach much more frequently than the former. From dissections it appears that the stomach has been often affected with inflammation, when neither pain nor fever had given any notice of it; and such is justly looked upon to have been of the erysipelatous kind. This kind of inflammation also is especially to be expected from acrimony of any kind applied to the stomach; and would certainly occur much more frequently, were not the interior surface of this organ commonly defended by mucus exuding in large quantity from the numerous follicles placed immediately under the villous coat. On many occasions, however, the exudation of mucus is prevented, or the liquid poured out is of a less viscid kind, so as to be less fitted to defend the subjacent nerves; and it is in such cases that acrid matters may readily produce an erysipelatous affection of the stomach.

In many cases this kind of inflammation cannot be discovered, as it takes place without pain, pyrexia, or vomiting: but in some it may; namely, when it spreads into the œsophagus, and appears on the pharynx and on the whole internal surface of the mouth. When therefore an erysipelatous inflammation affects the mouth and fauces, and there shall be at the same time in the stomach an unusual sensibility to all acrids, and also a frequent vomiting, there can be little doubt of the stomach's being affected in the same manner. Even when no inflammation appears in the fauces, if some degree of pain be felt in the stomach, if there be a want of appetite, an anxiety and frequent vomiting, an unusual sensibility with regard to acrids, some thirst, and frequency of pulse, there will then be room to suspect an inflammation in the stomach; and such symptoms, after some time, have been known to discover their cause by the inflammation rising to the fauces or mouth. Inflammation of this kind is often disposed to pass from one place to another on the same surface, and, in doing so, to leave the place it had at first occupied. Such an inflammation has been known to spread successively along the whole tract of the alimentary canal; occasioning, when in the intestines, diarrhœa, and in the stomach vomitings; the diarrhœa ceasing when the vomitings came on, and the vomitings on the coming on of the diarrhœa.

Causes, &c. An erysipelatous inflammation may arise from acrid matters taken into the stomach; or from some internal causes not yet well known. It frequently occurs in putrid diseases, and in those recovering from fevers.

Cure. When the disease is occasioned by acrid matters taken internally, and these may be supposed still present in the stomach, they are to be washed out by drinking a large quantity of warm and mild medicines, and exciting gentle vomiting. At the same time, if the nature of the acrimony and its proper corrector be known, this should be thrown in: or if a specific corrector be not known, some general demulcents should be employed.

These measures, however, are more suited to prevent than to cure inflammation after it has taken place. When this last may be supposed to have happened, if it be attended with a sense of heat, with pain and pyrexia, according to the degree of these symptoms, the measures proposed for the cure of the other kind are to be more or less employed. When an erysipelatous inflammation of the stomach has arisen from internal causes, if pain and pyrexia occur, bleeding may be employed in persons not otherwise weakened; but in case of its occurring in putrid diseases, or where the patients are already debilitated, bleeding is inadmissible; all that can be done being to avoid irritation, and only throwing into the stomach what quantity of acids and acescent aliments it shall be found able to bear. In some conditions of the body in which this disease is apt to occur, cinchona and bitters may seem to be indicated; but an erysipelatous state of the stomach will seldom allow them to be used.

Enteritis.

Genus XVI. ENTERITIS. 195

Inflammation of the *Intestines.*

Enteritis, *Sauv.* gen. 105. *Lin.* 29. *Vog.* 57. *Sag.* gen. 307.
Intestinorum inflammatio, *Boerh.* 959.
Febris intestinorum inflammatoria ex mesenterio, *Hoffm.* ii. 170.

Sp. I. *Enteritis Phlegmonodæa*, or the *Acute Enteritis.* 196

Enteritis iliaca, *Sauv.* sp. 1.
Enteritis colica, *Sauv.* sp. 2. *Boerh.* 963.

Description. This disease shows itself by a fixed pain in the abdomen, attended with fever, vomiting, and costiveness. The pain is often felt in different parts of the abdomen, but more frequently spreads over the whole, and is particularly violent about the navel.

Causes, &c. Inflammations of the intestines may arise from the same causes as those of the stomach; though commonly the former will more readily occur from cold applied to the lower extremities, or to the belly itself. It is also found supervening on the spasmodic colic, incarcerated hernia, and volvulus.

Prognosis. Inflammations of the intestines have the same terminations with those of the stomach, and the prognosis in both cases is much the same.

Cure. The cure of enteritis is in general the same with that of gastritis; but in this disease there is commonly more opportunity for the introduction of liquids, of acid, acescent, and other cooling remedies, and even of laxatives; but as a vomiting frequently attends the enteritis, care must be taken not to excite that vomiting by the quantity or quality of any thing thrown into the stomach. With regard to the suppuration

Phlegmasiæ. ration and gangrene of the intestines following the enteritis, the observations made respecting these terminations of gastritis are equally applicable in this disease.

197 Sp. II. *Enteritis Erysipelatosa*, or *Erysipelatous Enteritis.*

Concerning this nothing farther can be said, than what hath been already delivered concerning the gastritis.

198 Genus XVII. HEPATITIS.

Inflammation of the *Liver.*

Hepatitis, *Sauv.* gen. 113. *Lin.* 35. *Vog.* 58. *Sag.* gen. 312. *Boerh.* 914. *Hoffm.* ii. 14. *Junck.* 66.

Description. The inflammation of the liver is thought to be of two kinds, acute and chronic; but the latter very often does not discover itself except by an abscess found in the liver after death, and which is supposed to have been occasioned by some degree of inflammation; for this reason the chronic inflammation often escapes observation, and we shall here only treat of the acute hepatitis.

The acute hepatitis is attended with considerable fever; a frequent, strong, and hard pulse; high coloured urine; an acute pain in the right hypochondrium, increased by pressing upon the part. The pain is very often in such a part of the side as to make it appear like a pleurisy; and frequently, like that, is increased on inspiration. The disease is also commonly attended with a cough, which is generally dry, though sometimes moist; and when the pain thus resembles a pleurisy, the patient cannot lie easily except upon the side affected. The pain is frequently extended to the clavicle, and to the top of the shoulder; and is attended sometimes with hiccough, and sometimes with vomiting. Some have added jaundice, or a yellowness of the eyes, to the symptoms of this distemper; but experience shows that it has often occurred without any such symptom.

When hepatitis is of the chronic kind, depending more on an accumulation and effusion in the liver, than on an increased action of its small vessels, the patient complains rather of a sense of weight than of pain; and the fever is by no means either acute or constant: but it often returns in paroxysms somewhat resembling the attacks of an intermittent. This disease is very slow in its progress, frequently continuing for many months, and at last terminating in a very considerable suppuration. In most cases, however, it may be discovered by careful examination of the region of the liver externally. By this means a considerable enlargement of that viscus may in general be detected.

Causes, &c. The remote causes of hepatitis are not always to be discerned, and many have been assigned on a very uncertain foundation. It is principally a disease of warm climates. It has been supposed that the disease may be an affection either of the extremities of the hepatic artery, or those of the vena portarum; and the supposition is by no means improbable. The opinion, however, most commonly adopted is, that the acute hepatitis is an affection of the external membrane of the liver, and the chronic kind an affection of the parenchyma of that viscus. The acute disease may be seated either on the convex or concave surface of the liver; and in the former case a more pungent pain and hiccough may be produced, and the respiration is more considerably affected. In the latter there occurs less pain; and a vomiting is produced, commonly by some inflammation communicated to the stomach. The inflammation on the concave surface of the liver may be readily communicated to the gall-bladder and biliary ducts: and this, perhaps, is the only case of idiopathic hepatitis attended with jaundice.

Hepatitis.

Prognosis. The inflammation of the liver, like others, may end by resolution, suppuration, or gangrene; and the tendency to the one or to the other of those events may be known from what has been already mentioned concerning the prognosis in gastritis. The resolution of hepatitis is often the consequence of, or is attended with, evacuations of different kinds. A hæmorrhage sometimes from the nose, and sometimes from the hæmorrhoidal vessels, gives a solution of the disease. Sometimes the same thing is accomplished by a bilious diarrhœa; and sometimes the resolution is attended with sweating, and an evacuation of urine depositing a copious sediment. Sometimes it may be cured by an erysipelas appearing in some external part. When the disease has ended in suppuration, the pus collected may be discharged by the biliary ducts; or, if the suppurated part does not adhere anywhere closely to the neighbouring parts, it may be discharged into the cavity of the abdomen; but if, during the first state of inflammation, the affected part of the liver shall have formed a close adhesion to some of the neighbouring parts, the discharge after suppuration may be various, according to the different seat of the abscess. When seated on the convex part of the liver, if the adhesion be to the peritonæum lining the common teguments, the pus may make its way through these, and be discharged outwardly: or if the adhesion shall have been to the diaphragm, the pus may penetrate through this, and into the cells of the lungs; from whence it may be discharged by coughing. When the abscess is seated on the concave part of the liver, in consequence of adhesions, the pus may be discharged into the stomach or intestines; and into these last, either directly, or by the intervention of the biliary ducts. Upon a consideration of all these different circumstances, therefore, together with the general principles of inflammation, must the prognosis of this disease be established.

Cure. For the cure of hepatitis, we must have recourse to the general means of resolving other inflammatory disorders. Bleeding is to be used according to the degree of fever and pain. Blisters are to be applied: fomentations of the external parts, emollient clysters, gentle laxatives, diluents and refrigerants, are also useful. The cure, however, particularly in warm climates, where the disease is much more common than it is in Britain, is chiefly trusted to mercury. Not only in cases of the chronic kind, but in acute hepatitis also, after an attempt has been made to alleviate the urgent symptoms by bleeding and blistering, recourse is immediately had to this powerful mineral. It is employed by different practitioners, and in

Phlegmasiæ. in different cases, under various forms. Some are very fond of the use of calomel. But the preference is in general given, and perhaps with justice, to friction with mercurial ointment over the region of the liver. But under whatever form it may be employed, it is necessary that it should be introduced to such an extent as to keep the patient on the verge of salivation for some length of time; the duration being regulated by the circumstances of the case.

From the liberal use of mercury, there can be no doubt that a successful resolution has been obtained in many cases, which would otherwise have infallibly terminated in suppuration. But notwithstanding the most careful employment of it in some cases, suppuration will ensue; and then it is very doubtful whether any benefit will be derived from the continuance of it. But when a suppuration has been formed, and the abscess points outwardly, the part must be opened, the pus evacuated, and the ulcer healed according to the ordinary methods in use for healing abscesses and ulcers in other parts.

Chronic hepatitis often terminates in scirrhus. Against this, after mercury has failed, nitric acid taken internally has sometimes been employed with success.

Genus XVIII. SPLENITIS.

Inflammation of the Spleen.

Splenitis, *Sauv.* gen. 114. *Lin.* 36. *Vog.* 59. *Junck.* 67. *Sag.* gen. 313.
Lienis inflammatio, *Boerh.* 958. et *Van Swieten*, Comm.
Splenitis phlegmonodæa, *Sauv.* sp. 1. *Forest*, l. xx. obs. 5, 6. *De Haen*, apud *Van Swieten*, p. 958.
Pleuritis splenica, *Sauv.* sp. 3.
Splenalgia suppuratoria, *Sauv.* sp. 3.

Description. This disease, according to *Juncker*, comes on with a remarkable shivering, succeeded by a most intense heat and very great thirst; a pain and tumour are perceived in the left hypochondrium, and the paroxysms for the most part assume a quartan form. When the patients expose themselves for a little to the free air, their extremities immediately grow very cold. If a hæmorrhage happens, the blood flows out of the left nostril. The other symptoms are the same with those of the hepatitis. Like the liver, the spleen is also subject to a chronic inflammation, which often happens after agues; and the tumour which succeeds the inflammation is in many cases very considerable, and is called the *ague cake*, though that name is also frequently given to a scirrhous tumour of the liver succeeding intermittents.

Causes, &c. The causes of this distemper are in general the same with those of other inflammatory disorders; but those which determine the inflammation to that particular part more than another, are very much unknown. It attacks persons of a very plethoric and sanguine habit of body rather than others.

Prognosis. What has been said of the inflammation of the liver applies also to that of the spleen, though the latter is less dangerous than the former. Here also a vomiting of black matter, which in other acute diseases is such a fatal symptom, sometimes proves critical, according to the testimony of Juncker. Sometimes the hæmorrhoids prove critical: but very often the inflammation terminates by scirrhus.

Cure. This is not at all different from what has been already laid down concerning the hepatitis.

Nephritis.

Genus XIX. NEPHRITIS.

Inflammation of the Kidneys.

200

Nephritis, *Sauv.* gen. 115. *Lin.* 37. *Vog.* 65. *Sag.* gen. 314.
Nephritis vera, *Sauv.* sp. 1.

Description. The nephritis has the same symptoms which take place in other inflammations; but its distinguishing mark is the pain in the region of the kidney, which is sometimes obtuse, but more frequently pungent. The pain is not increased by the motion of the trunk of the body so much as a pain of the rheumatic kind affecting the same region. It may also frequently be distinguished by the pain shooting along the course of the ureter, and it is often attended with a drawing up of the testicle, and a numbness of the limb on the side affected; though indeed these symptoms most commonly attend the inflammation arising from a calculus in the kidney or ureter. The disease is also attended with frequent vomiting, and often with costiveness and colic pains. The urine is most commonly of a deep red colour, and is voided frequently and in a small quantity at a time. In more violent cases the urine is commonly colourless.

Causes, &c. The remote causes of this disease may be various; as external contusion, violent or long-continued riding; strains of the muscles of the back incumbent on the kidneys; various acrids in the course of circulation conveyed to the kidneys; and perhaps some other internal causes not yet well known: the most frequent is that of calculous matter obstructing the *tubuli uriniferi*, or calculi formed in the pelvis of the kidneys, and either sticking there or falling into the ureter.

Prognosis. This is not different from that of other inflammatory diseases.

Cure. When any of those causes operating as inducing the inflammation still continue to act, the first object in the cure must be the removal of these; but the principal intention to be had in view, is the resolution of the inflammation which has already taken place. But when, notwithstanding efforts for this purpose, the disease terminates in suppuration, it must be the endeavour of the practitioner to promote the discharge of the purulent matter, and the healing of the ulceration in the kidney.

These different objects are principally accomplished by bleeding, external fomentation, frequent emollient clysters, antiphlogistic purgatives, and by the free use of mild and demulcent liquids. The use of blisters is scarce admissible, or at least will require great care to avoid any considerable absorption of the cantharides.

The other species of nephritis enumerated by authors are only symptomatic.

Genus

Phlegmasiæ.

201 ## Genus XX. CYSTITIS.

Inflammation of the Bladder.

Cystitis, *Sauv.* gen. 108. *Lin.* 31. *Vog.* 66. *Sag.* gen. 309.
Inflammatio vesicæ, *Hoffm.* ii. 157.

202 The Cystitis from *Internal Causes.*

Cystitis spontanea, *Sauv.* sp. 1.

203 The Cystitis from *External Causes.*

Cystitis à cantharidibus, *Sauv.* sp. 2.
Cystitis traumatica, *Sauv.* sp. 3.

The inflammation of the bladder from internal causes is a very rare distemper; and when it does at any time occur, is to be cured in the same manner with other inflammations, avoiding only the use of blisters. When the disease arises from the internal use of these flies, camphor is recommended, besides other cooling medicines, and particularly cooling and emollient clysters.

204 ## Genus XXI. HYSTERITIS.

Inflammation of the Uterus.

Hysteritis, *Lin.* 38. *Vog.* 63.
Metritis, *Sauv.* gen. 107. *Sag.* gen. 315.
Inflammatio et febris uterina, *Hoffm.* II. 156.

Description. This disease is often confounded with that called the *puerperal* or *child-bed fever*; but is essentially distinct from it, as will be shown in its proper place. The inflammation of the uterus is often apt to terminate by gangrene: there is a pain in the head, with delirium; and the uterine region is so exceedingly tender, that it cannot bear the most gentle pressure without intolerable pain. When the *fundus uteri* is inflamed, there is a great heat, throbbing, and pain, above the pubes; if its posterior part, the pain is more confined to the loins and rectum, with a tenesmus; if its anterior part, it shoots from thence towards the neck of the bladder, and is attended with a frequent irritation to make water, which is voided with difficulty; and if its sides or the ovaria are affected, the pains will then dart into the inside of the thighs.

Causes, &c. Inflammations of the uterus, and indeed of the rest of the abdominal viscera, are very apt to take place in child-bed women; the reason of which seems to be the sudden change produced in the habit, and an alteration in the course of the circulating blood by the contraction of the uterus after delivery. The pressure of the gravid uterus being suddenly taken off from the *aorta descendens* after delivery, the resistance to the impulse of the blood passing through all the vessels derived from it, and distributed to the contiguous viscera, will be considerably lessened: it will therefore rush into those vessels with a force superior to their resistance; and, by putting them violently on the stretch, may occasion pain, inflammation, and fever. This contraction of the uterus also renders its vessels impervious to the blood which had freely passed through them for the service of the child during pregnancy; and consequently a much larger quantity will be thrown upon the contiguous parts, which will still add to their distention, and increase their tendency to inflammation.

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Prognosis. An inflammation of the uterus may in general be expected to produce an obstruction of the lochia; but the fever produced seldom proves fatal, unless the inflammation be violent, and end in a gangrene.

Cure. This is to be attempted by the same general means already recommended, and the management of this disorder entirely coincides with that of the puerperal fever.

Genus XXII. RHEUMATISMUS. 20

The *Rheumatism.*

Rheumatismus, *Sauv.* gen. 185. *Lin.* 62. *Vog.* 138. *Boerh.* 1400. *Junck.* 19.
Dolores rheumatici et arthritici, *Hoffm.* II. 317.
Myositis, *Sag.* gen. 301.

The *Acute Rheumatism.*

Rheumatismus acutus, *Sauv.* sp. 1.
Rheumatismus vulgaris, *Sauv.* sp. 2.

A. The Lumbago, or *Rheumatism in the Muscles of the Loins.* 20

Lumbago rheumatica, *Sauv.* gen. 212. *Sag.* p. 1.
Nephralgia rheumatica, *Sauv.* sp. 4.

B. The Sciatica, *Ischias,* or *Hip-Gout.* 20

Ischias rheumaticum. *Sauv.* 213. sp. 10.

C. The *Bastard Pleurisy,* or *Rheumatism in the Muscles of the Thorax.* 20

Pleurodyne rheumatica, *Sauv.* gen. 148. sp. 3.
Pleuritis spuria, *Boerh.* 878.

The other species, which are very numerous, are all symptomatic; as,
Lumbago plethorica, *Sauv.* sp. 3.
Ischias sanguineum, *Sauv.* sp. 2.
Pleurodyne plethorica, *Sauv.* sp. 1.
Rheumatismus hystericus, *Sauv.* sp. 7.
Ischias hystericum, *Sauv.* sp. 3.
Pleurodyne hysterica, *Sauv.* sp. 6.
Rheumatismus saltatorius, *Sauv.* sp.
Pleurodyne flatulenta, *Sauv.* sp. 4.
Pleurodyne à spasmate, *Sauv.* sp. 9.
Rheumatismus scorbuticus, *Sauv.* sp. 4.
Lumbago scorbutica, *Sauv.* sp. 5.
Pleurodyne scorbutica, *Sauv.* sp. 11.
Ischias syphiliticum, *Sauv.* sp. 7.
Pleurodyne venerea, *Sauv.* sp. 5.
Lumbago sympathica, *Sauv.* sp. 13.
Lumbago à saburrâ, *Sauv.* sp. 8.
Pleurodyne à cacochyliâ, *Sauv.* sp. 7.
Rheumatismus saltatorius verminosus, *Sauv.* sp. 8.
Ischias verminosum, *Sauv.* sp. 8.
Pleurodyne verminosa, *Sauv.* sp. 2.
Rheumatismus metallicus, *Sauv.* sp. 10.
Lumbago à hydrothorace, *Sauv.* sp. 14.
Lumbago pseudoischuria, *Sauv.* sp. 16.
Pleurodyne à rupto œsophago, *Sauv.* sp. 20.
Pleurodyne rachitica, *Sauv.* sp. 13.
Ischias à sparganosi, *Sauv.* sp. 5.
Pleurodyna catarrhalis, *Sauv.* sp. 14.

Rheumatismus

Phlegmasiæ.

Rheumatismus necroseos, *Sauv.* sp. 14.
Rheumatismus dorsalis, *Sauv.* sp. 11.
Lumbago à satyriasi, *Sauv.* sp. 15.
Rheumatismus febricosus, *Sauv.* sp. 9.
Lumbago febrilis, *Sauv.* sp. 4.
&c. &c.

Description. The rheumatism is particularly distinguished by pains affecting the joints, and for the most part the joints alone; but sometimes also the muscular parts. Very often they shoot along the course of the muscles from one joint to another, and are always much increased by the action of the muscles belonging to the joint or joints affected. The larger joints are those most frequently affected, such as the hip-joint and knees, of the lower extremities, and the shoulders and elbows of the upper ones. The ancles and wrists are also frequently affected; but the smaller joints, such as those of the toes or fingers, seldom suffer. Sometimes the disease is confined to one part of the body, yet very frequently it affects many parts; and then it begins with a cold stage, which is immediately succeeded by the other symptoms of pyrexia, and particularly by a frequent, full, and hard pulse. Sometimes the pyrexia is formed before any pains are perceived; but more commonly pains are felt in particular parts before any symptoms of fever occur. When no pyrexia is present, the pain may be confined to one joint only; but when any considerable pyrexia takes place, though the pain may chiefly be felt in one joint, yet it seldom happens that it does not affect several joints, often at the very same time, but for the most part shifting their place, and having abated in one joint they become more violent in another. They do not commonly remain long in the same joint, but frequently shift from one to another, and sometimes return to joints formerly affected; and in this manner the disease often continues for a long time. The fever attending these pains has an exacerbation every evening, and is most considerable during the night, when the pains also become more violent; and it is at the same time that the pains shift their place from one joint to another. These seem to be also increased during the night by the body being covered more closely, and kept warmer.

A joint, after having been for some time affected with pain, commonly becomes also affected with some swelling and redness, which is painful to the touch. It seldom happens that a swelling coming on does not take off the pain entirely, but it rarely secures the joint against a return of it. This disease is commonly attended with more or less sweating, which occurs early, but is seldom free or copious, and seldom proves critical, though it may give temporary relief of the pain. The urine is high-coloured, and in the beginning without sediment. This, however, does not prove entirely critical, for the disease often continues long after such a sediment has appeared in the urine. The blood is always sizy. The acute rheumatism differs from all other inflammatory diseases, in not being liable to terminate in suppuration: this almost never happens; but the disease sometimes produces effusions of a transparent gelatinous fluid into the sheaths of the tendons: but if these effusions be frequent, it is certain that the liquor must often be absorbed; for it very seldom happens, that considerable or permanent tumours have been produced, or such as required to be opened and to have the contained fluid evacuated. Such tumours, however, have sometimes occurred, and the opening made in them has produced ulcers very difficult to heal.

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Sometimes rheumatism will continue for several weeks; but it seldom proves fatal, and it is rare that the pyrexia continues to be considerable for more than two or three weeks. While the pyrexia abates in its violence, if the pains of the joints continue, they are less violent; more limited in their place, being confined commonly to one or a few joints only; and are less ready to change their place.

It is often a very difficult matter to distinguish rheumatism from gout: but in rheumatism there in general occurs much less affection of the stomach; it affects chiefly the larger joints, and several of these are often affected with severe pain at the same time: it occurs at an earlier period of life than gout; it is not observed to be hereditary; and it can in general be traced to some obvious exciting cause, particularly to the action of cold.

Causes, &c. This disease is frequent in cold, and more uncommon in warm climates. It appears most frequently in autumn and spring; less frequently in winter, while the frost is constant; and very seldom during the heat of summer. It may, however, occur at any season, if vicissitudes of heat and cold be for the time frequent. For the most part, the acute rheumatism arises from the application of cold to the body when unusually warm; or when the cold is applied to one part of the body, whilst the other parts are kept warm; or, lastly, when the application of the cold is long continued, as when moist or wet clothes are applied to any part of the body.—These causes may affect persons of all ages; but the rheumatism seldom appears either in very young or in elderly persons, and most commonly occurs from the age of puberty to that of 35. These causes may also affect persons of any constitution, but they most commonly affect those of a sanguine temperament.

With respect to the proximate cause of rheumatism, there have been various opinions. It has been imputed to a peculiar acrimony; of which, however, there is no evidence; and the consideration of the remote causes, the symptoms, and cure, render it very improbable. A disease of a rheumatic nature, however, may be occasioned by an acrid matter applied to the nerves, as is evident from the toothach, a rheumatic affection generally arising from a carious tooth. Pains arising from deep-seated suppurations may also resemble the rheumatism; and many cases have occurred in which such suppurations occasioned pains resembling the lumbago and ischias; but from what has been already said, it seems improbable that ever any pure rheumatic case should end in suppuration.

The proximate cause of rheumatism has by many been supposed to be a lentor in the fluids obstructing the vessels of the part; but in the observations formerly made, sufficient reasons have been already laid down for rejecting the doctrine of lentor. While we cannot therefore find either evidence or reason for supposing that the rheumatism depends on any change in the state of the fluids, we must conclude that the proximate cause of it is the same with that of other inflammations not depending upon a direct stimulus.

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In the case of rheumatism, it is supposed that the most common remote cause of it, that is, cold applied, operates especially on the vessels of the joints, these being less covered by a cellular texture than those of the intermediate parts of the limbs. It is farther supposed, that the application of cold produces a constriction of the extreme vessels, and at the same time an increase of tone or phlogistic diathesis in the course of them, from which arises an increased impetus of the blood, and at the same time a resistance to the free passage of it, and consequently inflammation and pain. It is also supposed, that the resistance formed excites the *vis medicatrix* to a further increase of the impetus of the blood; and to support this, a cold stage arises, a spasm is formed, and a pyrexia and phlogistic diathesis are produced in the whole system.

Hence the cause of rheumatism appears to be exactly analogous to that of inflammations depending on an increased afflux of blood to a part while it is exposed to the action of cold. But there seems to be further in this disease some peculiar affection of the muscular fibres. These seem to be under some degree of rigidity: and therefore less easily admit of motion, and are pained upon the exertions of it. This also seems to be the affection which gives opportunity to the propagation of pains from one joint to another, and which are most severely felt in the extremities terminating in the joints, because beyond these the oscillations are not propagated. This affection of the muscular fibres explains the manner in which strains and spasms produce rheumatic affections; and, on the whole, shows, that with an inflammatory affection of the sanguiferous system, there is also in rheumatism a peculiar affection of the muscular fibres, which has a considerable share in producing the phenomena of the disease. And it would even appear, that in what has commonly been called *acute rheumatism*, in contradistinction to the chronic, of which we are next to treat, there exists not only a state of active inflammation in the affected parts, but also of peculiar irritability; and that this often remains after the inflammation is very much diminished or has even entirely ceased. Hence a renewal of the inflammation and recurrence of the pain take place from very slight causes; and in the treatment of the disease both the state of inflammation and irritability must be had in view.

Cure. For counteracting the state of active inflammation, the chief aim of the practitioner must be to diminish the general impetus of the circulation, and the impetus at the part particularly affected. For counteracting the state of irritability, he must endeavour to remove the disposition to increased action in the vessels; to prevent the action of causes exciting painful sensations; and to obviate their influence on the part. The cure therefore requires, in the first place, an antiphlogistic regimen, and particularly a total abstinence from animal food, and from all fermented or spirituous liquors; substituting a mild vegetable or milk diet, and the plentiful use of soft diluting liquors. On this principle also, blood-letting is the chief remedy of acute rheumatism. The blood is to be drawn in large quantity; and the bleeding is to be repeated in proportion to the frequency, fulness, and hardness of the pulse, and the violence of the pain. For the most part, large and repeated bleeding during the first days of the disease seem to be necessary, and accordingly have been very much employed; but to this some bounds are to be set; for very profuse bleedings occasion a slow recovery, and are ready to produce a chronic rheumatism.

To avoid that debility of the system which general bleedings are apt to occasion, the urgent symptom of pain may be often relieved by topical bleedings; and when any swelling or redness has come upon a joint, the pain may very certainly be relieved by this evacuation: but as the pain and continuance of the disease seem to depend more upon the phlogistic diathesis of the whole system than upon the affection of particular parts, so topical bleedings will not supply the place of the general bleedings proposed above in most instances.

To take off the phlogistic diathesis prevailing in this disease, purging may be useful, if procured by medicines which do not stimulate the whole system, as neutral salts, and other medicines which have a refrigerant power. Purging, however, is not so useful as bleeding in removing the phlogistic diathesis; and when the disease has become general and violent, frequent stools are inconvenient, and even hurtful, by the motion and pain which they occasion.

Next to blood-letting, nothing is of so much service, both in alleviating the pains in this disease and in removing the phlogistic diathesis, as the use of sudorifies: and of all the medicines belonging to this class, what has commonly been known by the name of Dover's powder, a combination of powder of ipecacuan and opium, is the most convenient and the most effectual. Copious sweating, excited by this medicine, and supported for 10 or 12 hours by tepid diluents, such as decoction of the woods, or the like, will in most instances produce a complete remission of the pain: and by this practice, combined with blood-letting and proper regimen, the disease may often be entirely removed.

If, however, after complete intermissions from pain for some length of time have been obtained by these means, it be found that there is a great tendency to a return of the pains without any obvious cause, recourse may be had with very great benefit to the use of the Peruvian bark. By the early use of this, where a complete intermission from pain is obtained, the necessity of repeated blood-letting and sweating is often superseded; but where a complete remission cannot be obtained, it has been suspected by some to be hurtful: and in these cases, when blood-letting and sudorifics have been pushed as far as may be thought prudent, without being productive of the desired effect, very great benefit is often derived from the use of calomel combined with opium, as recommended in the Edinburgh Medical Commentaries, by Dr Hamilton of Lynn Regis.

In this disease, external applications are of little service. Fomentations in the beginning of the disease rather aggravate than relieve the pains. The rubefacients and camphire are more effectual: but they commonly only move them from one part to another, and do not prove any cure of the general affection. Blistering may also be very effectual in removing the pain

pain from a particular part; but will be of little use, except where the pains are much confined to one place.

ARTHRODYNIA, or *Chronic Rheumatism.*

Rheumatismus chronicus Auctorum.

Description. When the pyrexia attending the acute rheumatism has ceased; when the swelling and redness of the joints are entirely gone, but pains still continue to affect certain joints, which remain stiff, feel uneasy upon motion, changes of weather, or in the night time only, the disease is then called the *chronic rheumatism*, as it often continues for a very long time.

The limits between the acute and chronic rheumatisms are not always exactly marked. When the pains are still ready to shift their place; when they are especially severe in the night time; when, at the same time, they are attended with some degree of pyrexia, and with some swelling, and especially some redness of the joints; the disease is to be considered as partaking of the nature of the acute rheumatism. But when there is no longer any degree of pyrexia remaining; when the pained joints are without redness; when they are cold and stiff; when they cannot easily be made to sweat; or when, while a free and warm sweat is brought out on the rest of the body, it is only clammy and cold on the pained joints; and when, further, the pains of these are increased by cold, and relieved by heat, applied to them; the case is to be considered as that of a purely chronic rheumatism: or, perhaps more properly, the first of the conditions now described may be termed the state of irritability, and the second the state of atony.

The chronic rheumatism, or rather the atonic, may affect different joints; but is especially apt to affect those which are surrounded with many muscles, and those of which the muscles are employed in the most constant and vigorous exertions. Such is the case of the vertebræ of the loins, the affection of which is named *lumbago;* or of the hip joint, when the disease is named *ischias* or *sciatica.*

Violent strains and spasms occurring on sudden and somewhat violent exertions, bring on rheumatic affections, which at first partake of the acute, but very soon change into the nature of the chronic, rheumatism.—Such are frequently the lumbago, and other affections, which seem to be more seated in the muscles than in the joints. The distinction of the rheumatic pains from those resembling them which occur in the siphylis and scurvy must be obvious, either from the seat of the pains, or from the concomitant symptoms peculiar to those diseases. The distinction of the rheumatism from the gout will be more fully understood from what is laid down under the genus Podagra.

Causes, &c. The phenomena of the purely chronic rheumatism lead us to conclude, that its proximate cause is an atony both of the blood-vessels and of the muscular fibres of the part affected, together with such a degree of rigidity and contraction in the latter as frequently attend them in a state of atony: and indeed this atony, carried to a certain extent, gives rise to a state of paralysis, with an almost total loss of motion in the affected limbs. The paralytic state of rheumatism therefore may be pointed out as a fourth condition of the disease, often claiming the attention of the practitioner.

Cure. From the view just now given of the proximate cause of chronic rheumatism, the chief indication of cure must be, to restore the activity and vigour of the part, which is principally to be done by increasing the tone of the moving fibres, but which may sometimes also be aided by giving condensation to the simple solid. When, however, the disease has degenerated into the state of paralysis, the objects to be aimed at are, the restoration of a due condition to the nervous energy in the part affected; the obtaining free circulation of blood through the vessels of the part; and the removal of rigidity in membranes and ligaments.

For answering these purposes, a great variety of remedies, both external and internal, are had recourse to. The chief of the external are, the supporting the heat of the part, by keeping it constantly covered with flannel; the increasing the heat of the part by external heat, applied either in a dry or humid form; the diligent use of the flesh-brush, or other means of friction; the application of electricity in sparks or shocks; the application of cold water by affusion or immersion; the application of essential oils of the most warm and penetrating kind; the application of salt brine; the employment of the warm bath or of the vapour baths, either to the body in general or to particular parts; and, lastly, the employment either of exercise of the part itself as far as it can easily bear, or by riding or other modes of gestation.

The internal remedies are, large doses of essential oils drawn from resinous substances, such as turpentine; substances containing such oils, as guaiac.; volatile alkaline salts, &c. These or other medicines are directed to procure sweat; and calomel, or some other preparation of mercury, in small doses, may be continued for some time. But of all the remedies which have been found useful in atonic rheumatism, perhaps the best is cinchona. It is particularly serviceable in the earlier periods of the disease. It has often been highly efficacious in preventing the degeneracy of the inflammatory into the atonic state of the disease; and by some practitioners, particularly Dr Haygarth of Bath, it has been highly extolled in acute rheumatism. Besides these, there are several other remedies recommended. The cicuta, aconitum, and hyosciamus, have in particular been highly extolled; and an infusion of the rhododendron chrysanthum is said to be employed by the Siberians with very great success. An account of the Siberian mode of practice is given by Dr Matthew Guthrie of Petersburgh, in the fifth volume of the Edinburgh Medical Commentaries, and has been followed with success at other places. Among other internal remedies for rheumatism, the use of arsenic has of late been recommended by Dr Bardsley of Liverpool. It is advised to be given under the form of the mineral solution proposed by Dr Fowler as a remedy in intermittent fever and in periodic headachs. Under this form, it is now ascertained by extensive experience that arsenic may be taken internally with as much safety as any other active medicine; and in some cases of rheumatism in which it has been employed at Edinburgh, there is reason to believe that it has been productive of benefit.

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Podagra

210 Genus XXIII. ODONTALGIA, the Toothach.

Odontalgia, *Sauv.* gen. 198. *Lin.* 45. *Vog.* 145. *Sag.* gen. 159. *Junck.* 25.
Odontalgia sive rheumatismus odontalgicus, *Hoffm.* II. 330.
Odontalgia cariosa, *Sauv.* sp. 1.
Odontalgia scorbutica, *Sauv.* sp. 4.
Odontalgia catarrhalis, *Sauv.* sp. 3.
Odontalgia arthritica, *Sauv.* sp. 6.
Odontalgia gravidarum, *Sauv.* sp. 2.
Odontalgia hysterica, *Sauv.* sp. 8.
Odontalgia stomachica, *Sauv.* sp. 9.

Description. This well-known disease makes its attack by a most violent pain in the teeth, most frequently in the *molares*, more rarely in the *incisores*, reaching sometimes up to the eyes, and sometimes backward into the cavity of the ear. At the same time there is a manifest determination to the head; and a remarkable tension and inflation of the vessels takes place, not only in the parts next to that where the pain is seated, but over the whole head.

Causes, &c. The toothach is sometimes merely a rheumatic affection, arising from cold, but more frequently from a carious tooth. It is also a symptom of pregnancy, and takes place in some nervous disorders; it may attack persons at any time of life, though it is most frequent in the young and plethoric.

Cure. Many empirical remedies have been proposed for the cure of the toothach, but none have in any degree answered the purpose. When the affection is purely rheumatic, blistering behind the ear will almost always remove it; but when it proceeds from a carious tooth, the pain is much more obstinate. In this case it has been recommended to touch the pained part with a hot iron, or with sulphuric acid, in order to destroy the aching nerve; to hold strong spirits in the mouth; to put a drop of oil of cloves into the hollow of the tooth, or a pill of equal parts of opium and camphor: but one of the most useful applications of this kind is strong nitrous acid, diluted with three or four times its weight of spirit of wine, and introduced into the hollow of a tooth from which great pain arises, either by means of a hair pencil or a little cotton. Cinchona has also been recommended, and perhaps with more justice, on account of its tonic and antiseptic powers; but very often all these remedies will fail, and the only infallible cure is the extraction of the tooth. See Surgery.

211 Genus XXIV. PODAGRA, the Gout.

Podagra, *Vog.* 175. *Boerh.* 1254.
Febris podagrica, *Vog.* 69.
Arthritis, *Sauv.* gen. 183. *Lin.* 60. *Vog.* 139. *Sag.* gen. 142.
Dolor podagricus et arthriticus verus, *Hoffm.* II. 339.
Dolores arthritici, *Hoffm.* II. 317.
Affectus spastico-arthritici, *Junck.* 46.

212 Sp. I. The *Regular* Gout.

Arthritis podagrica, *Sauv.* sp. 1.
Arthritis rachialgica, *Sauv.* sp. 11.
Arthritis æstiva, *Sauv.* sp. 4.

Sp. II. The *Atonic* Gout. 213

Arthritis melancholica, *Sauv.* sp. 6.
Arthritis hiemalis, *Sauv.* sp. 2.
Arthritis chlorotica, *Sauv.* sp. 5.
Arthritis asthmatica, *Sauv.* sp. 9.

Sp. III. The *Retrocedent* Gout. 214

Sp. IV. The *Misplaced* Gout. 215

Description. What we call a *paroxysm of the gout* is principally constituted by an inflammatory affection of some of the joints. This sometimes comes on suddenly, without any warning, but is generally preceded by several symptoms; such as the ceasing of a sweating which the feet had been commonly before affected with; an unusual coldness of the feet and legs; a frequent numbness, alternating with a sense of prickling along the whole of the lower extremities; frequent cramps of the muscles of the legs; and an unusual turgescence of the veins.

While these symptoms take place in the lower extremities, the body is affected with some degree of torpor and languor, and the functions of the stomach in particular are more or less disturbed. The appetite is diminished; and flatulency, or other symptoms of indigestion, are felt. These symptoms take place for several days, sometimes for a week or two, before a paroxysm comes on; but commonly, upon the day immediately preceding it, the appetite becomes keener than usual.

The circumstances of paroxysms are chiefly the following. They come on most commonly in the spring, and sooner or later according as the vernal heat succeeds sooner or later to the winter's cold, and, perhaps, sooner or later also, according as the body may happen to be more or less exposed to vicissitudes of heat and cold.

The attacks are sometimes felt first in the evening, but more commonly about two or three o'clock in the morning. The paroxysm begins with a pain affecting one foot, most frequently in the ball or first joint of the great toe, but sometimes in other parts of the foot. With the attack of this pain, there is commonly more or less of a cold shivering; which, as the pain increases, gradually ceases; and is succeeded by a hot stage of pyrexia, which continues for the same time with the pain itself. From the first attack, the pain becomes, by degrees, more violent, and continues in this state with great restlessness of the whole body till next midnight, after which it gradually remits; and, after it has continued for twenty-four hours from the commencement of the first attack, it commonly ceases almost entirely; and, with the coming on of a gentle sweat, allows the patient to fall asleep. The patient, upon coming out of this sleep in the morning, finds the pained part affected with some redness and swelling, which, after having continued for some days, gradually abate.

When a paroxysm has thus come on, although the violent pain after 24 hours be considerably abated, the patient is not entirely relieved from it. For some days

days he has every evening a return of more considerable pain and pyrexia, and these continue with more or less violence till morning. After going on, in this manner, for several days, the disease sometimes goes entirely off, not to return till after a long interval.

When the disease, after having thus remained for some time in a joint, ceases entirely, it generally leaves the person in very perfect health, enjoying greater ease and alacrity in the functions of both body and mind than he had for a long time before experienced.

At the beginning of the disease, the returns of it are sometimes only once in three or four years: but as it advances, the intervals become shorter, and at length the attacks are annual; afterwards they come twice each year; and at length recur several times during the course of autumn, winter, and spring; and as, when the fits are frequent, the paroxysms become also longer, so, in the advanced state of the disease, the patient is hardly ever tolerably free from it, except perhaps for two or three months in summer.

The progress of the disease is also marked by the parts which it affects. At first, it commonly affects one foot only; afterwards every paroxysm affects both feet, the one after the other; and as the disease proceeds, it not only affects both feet at once, but, after having ceased in the foot which was last attacked, returns again into the first, and perhaps a second time also into the other. Its changes of places are not only from one foot to another, but from the feet into other joints, especially those of the upper extremities; so that there is hardly a joint of the body which, on one occasion or another, is not affected. It sometimes affects two different joints at the very same time; but more commonly it is at any one time severe in a single joint only, and passes in succession from one joint to another; so that the patient's affliction is often protracted for a long time.

When the disease has often returned, and the paroxysms have become very frequent, the pains are commonly less violent than they were at first; but the patient is more affected with sickness, and the other symptoms of the atonic gout, which shall be hereafter mentioned.

After the first paroxysm of the disease, the joints which have been affected are entirely restored to their former suppleness and strength: but after the disease has recurred very often, the joints affected do neither so suddenly nor entirely recover their former state, but continue weak and stiff; and these effects at length proceed to such a degree, that the joints lose their motion entirely.

In many persons, but not in all, after the disease has frequently recurred, concretions of a chalky nature are formed upon the outside of the joints, and for the most part immediately under the skin. The matter seems to be deposited at first in a fluid form, afterwards becoming dry and firm. In their firm state, these concretions are a hard earthy substance, very entirely soluble in acids. After they have been formed, they contribute, with other circumstances, to destroy the motion of the joints.

In most persons who have laboured under the gout for many years, a nephritic affection comes on, and discovers itself by all the symptoms which usually attend calculous concretions in the kidneys, and which we shall have occasion to describe in another place. All that is necessary to be observed here is, that the nephritic affection alternates with paroxysms of the gout; and that the two affections, the nephritic and the gouty, are hardly ever present at the same time. This also may be observed, that children of gouty or nephritic parents commonly inherit one or other of these diseases; but whether the principal disease of the parent may have been either gout or nephritis alone, some of the children have the one and some the other. In some of them the nephritic affection occurs alone, without any gout supervening; and this happens to be frequently the case with the female children of gouty parents.

In the whole of the history already given, we have described the most common form of the disease, and which therefore, however diversified in the progress of it, may be still called the regular state of the gout.—Upon some occasions, however, the disease assumes different appearances: but as we suppose the disease to depend always upon a certain diathesis, or disposition of the system; so every appearance which we can perceive to depend upon that same disposition, we still consider as symptomatic, and view the disease to be a case of the gout. The principal circumstance, in what we term the *regular gout*, is the inflammatory affection of the joints; and whatever symptoms we can perceive to be connected with, or to depend upon, the disposition which produces that inflammatory affection, but without its taking place or being present at the same time, we name the *irregular gout*.

Of such irregular gout there are three different states, which may be named the *atonic*, the *retrocedent*, and the *misplaced* gout.

The first is, when the gouty diathesis prevails in the system; but, from certain causes, does not produce the inflammatory affection of the joints. In this case, the morbid symptoms which appear, are chiefly affections of the stomach, such as loss of appetite, indigestion, and its various attendants of sickness, nausea, vomiting, flatulency, acid eructations, and pains in the region of the stomach. These symptoms are frequently accompanied with pains and cramps in several parts of the trunk and the upper extremities of the body, which are relieved by the discharge of wind from the stomach. Together with these affections of the stomach, there commonly occurs a costiveness; but sometimes a looseness, with colic pains. These affections of the alimentary canal are often attended with all the symptoms of hypochondriasis, such as dejection of mind, a constant and anxious attention to the slightest feelings, an imaginary aggravation of these, and an apprehension of danger from them.

In the same atonic gout, the viscera of the thorax also are sometimes affected, and palpitations, faintings, and asthma occur.

In the head also occur headachs, giddiness, apoplectic and paralytic affections.

When the several symptoms now mentioned occur in habits having the marks of a gouty disposition, this may be suspected to have laid the foundation for them; and especially when either, in such habits, a manifest tendency to the inflammatory affection has formerly appeared, or when the symptoms mentioned are

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Another state of the disease we name the *retrocedent* gout. This occurs when an inflammatory state of the joints has, in the usual manner, come on, but without arising to the ordinary degree of pain and inflammation; or at least without these continuing for the usual time, or without their receding gradually in the usual manner; these affections of the joints suddenly and entirely cease, while some internal part becomes affected. The internal part most commonly attacked is the stomach; which then is affected with anxiety, sickness, vomiting, or violent pain: but sometimes the internal part is the heart, which gives occasion to a syncope; sometimes it is the lungs, which are affected with asthma: and sometimes it is the head, giving occasion to apoplexy or palsy. In all these cases there can be no doubt that the symptoms are all a part of the same disease, however different the affection may seem to be in the parts which it attacks.

The third state of irregular gout, which we name the *misplaced*, is when the gouty diathesis, instead of producing the inflammatory affection of the joints, produces an inflammatory affection of some internal part, and which appears from the same symptoms that attend the inflammations of those parts arising from other causes.

Whether the gouty diathesis does ever produce such inflammation of the internal parts without having first produced it in the joints, or whether the inflammation of the internal part be always a translation from the joints previously affected, we dare not determine; but, even supposing the latter to be always the case, we think the difference of the affection of the internal part must still distinguish the *misplaced* from what we have named the *retrocedent gout*.

With regard to the misplaced gout, Dr Cullen, whom we here follow, tells us, that he never met with any cases of it in his practice, nor does he find any distinctly marked by practical writers, except that of a pneumonic inflammation.

There are two cases of a translated gout; the one of which is an affection of the neck of the bladder, producing pain, strangury, and a *catarrhus vesicæ*: the other is an affection of the rectum, sometimes indicated by pain alone in that part, and sometimes by hæmorrhoidal symptoms. In gouty persons such affections have been known to alternate with inflammatory affections of the joints; but whether these belong to the retrocedent or to the misplaced gout, Dr Cullen pretends not to determine.

It is commonly supposed, that there are some cases of rheumatism which are scarcely to be distinguished from the gout: but these, Dr Cullen thinks, are but few; and that the two diseases may be for the most part distinguished with great certainty, by observing the predisposition, the antecedent circumstances, the parts affected, the recurrences of the disease, and its connection with the system; which circumstances, for the most part, appear very differently in the two diseases.

Causes, &c. The gout is generally an hereditary disease: but some persons, without any hereditary disposition, seem to acquire it; and in some an hereditary disposition may be counteracted from various causes. Podagra. It attacks the male sex especially; but it sometimes, though more rarely, attacks also the female. The females liable to it are those of the more robust and full habits; and it very often happens to those before the menstrual evacuation has ceased. Dr Cullen hath also found it occurring in several females whose menstrual evacuations were more abundant than usual.

The gout seldom attacks eunuchs; and when it does, seems to fall upon those who happen to be of a robust habit, to lead an indolent life, and to live very full. It attacks especially men of robust and large bodies, who have large heads, are of full and corpulent habits, and whose skins are covered with a thick *rete mucosum*, which gives a coarse surface. To speak in the style of the ancient physicians, the gout will seldom be found to attack those of a sanguine, or such as are of a purely melancholic temperament; but very readily those of a *cholerico-sanguine* temperament. It is, however, very difficult to treat this matter with precision. The gout seldom attacks persons employed in constant bodily labour, or those who live much upon vegetable aliment. It does not commonly attack men till after the age of 35; and generally not till a still later period. There are indeed instances of the gout appearing more early, but these are few in comparison of the others. When the disease does appear early in life, it seems to be in those who have the hereditary disposition very strong, and to whom the remote causes hereafter mentioned have been applied in a very considerable degree.

As the gout is an hereditary disease, and affects men particularly of a certain habit, its remote causes may be considered as predisponent and occasional. The predisponent cause, as far as expressed by external appearances, has been already marked; and physicians have been very confident in assigning the occasional causes: but in a disease depending so much upon a predisposition, the assigning occasional causes must be uncertain; as in the predisposed the occasional causes may not always appear, and in persons not predisposed they may appear without effect; and this uncertainty must particularly affect the case of the gout.

The occasional causes of the disease seem to be of two kinds. First, Those which induce a plethoric state of the body. Secondly, Those which in plethoric habits, induce a state of debility. Of the first kind are a sedentary, indolent manner of life, and a full diet of animal food. Of the second kind of occasional causes which induce debility are excess in venery; intemperance in the use of intoxicating liquors; indigestion, produced either by the quantity or quality of the aliments; much application to study or business, night watching, excessive evacuations; the ceasing of usual labour; a sudden change from a very full to a very spare diet; the large use of acids and acescents; and, lastly, cold applied to the lower extremities. The former seem to act by increasing the predisposition; the latter are commonly the exciting causes, both of the first attacks, and of the repetitions of the disease.

With respect to the proximate cause of the gout, it has generally been thought that it depends on a certain

tain morbific matter always present in the body; and that this matter, by certain causes, thrown upon the joints or other parts, produces the several phenomena of the disease.

This doctrine, however ancient and generally received, appears to Dr Cullen to be very doubtful. For,

First, There is no direct evidence of any morbific matter being present in persons disposed to the gout. There are no experiments or observations which show that the blood or other humours of gouty persons are in any respect different from those of the sound. Previous to attacks of the gout, there appear no marks of any morbid state of the fluids; for the disease generally attacks those persons who have enjoyed the most perfect health, and appear to be in that state when the disease comes on. At a certain period of the disease, a peculiar matter indeed appears in gouty persons; but this, which does not appear in every instance, and which appears only after the disease has subsisted for a long time, seems manifestly to be the effect, not the cause, of the disease. Further, Though there be certain acrids which, taken into the body, seem to excite the gout, it is probable that these acrids operate otherwise in exciting the disease, than by affording the material cause of it. In general, therefore, Dr Cullen thinks there is no proof of any morbific matter being the cause of the gout.

Secondly, The suppositions concerning the particular nature of the matter producing the gout, have been so various, and so contradictory, as to allow us to conclude, that there is truly no proof of the existence of any of them. With respect to many of these suppositions, they are so inconsistent with chemical philosophy, and with the laws of the animal economy, that they must be entirely rejected.

Thirdly, The supposition of a morbific matter as the cause, is not consistent with the phenomena of the disease, particularly with its frequent and sudden translations from one part to another.

Fourthly, The supposition is further rendered improbable by this, that if a morbific matter did exist, its operation should be similar in the several parts which it attacks: whereas it seems to be very different, being stimulant and exciting inflammation, in the joints; but sedative and destroying tone in the stomach; which, upon the supposition of the same particular matter acting in both cases, is not to be explained by any difference in the part affected.

Fifthly, Some facts alleged in proof of a morbific matter, are not confirmed; such as those which would prove the disease to be contagious. There is, however, no proper evidence of this, the facts given being not only few, but exceptionable, and the negative observations innumerable.

Sixthly, Some arguments brought in favour of a morbific matter are founded upon a mistaken explanation. The disease has been supposed to depend upon a morbific matter, because it is hereditary. But the inference is not just: for most hereditary diseases do not depend upon any morbific matter, but upon a particular conformation of the structure of the body transmitted from the parent to the offspring; and this last appears to be particularly the case in the gout. It may be also observed, that hereditary diseases depending upon a morbific matter, appear always much more early in life than the gout commonly does.

Seventhly, The supposition of a morbific matter being the cause of the gout, has been hitherto useless, as it has not suggested any successful method of cure. Particular theories of gout have often corrupted the practice, and have frequently led from those views which might have been useful, and from that practice which experience had approved. Further, Though the supposition of a morbific matter has been generally received, it has been as generally neglected in practice. When the gout has affected the stomach, nobody thinks of correcting the matter supposed to be present there, but merely of restoring the tone of the moving fibres.

Eightly, The supposition of a morbific matter is quite superfluous: for it explains nothing, without supposing that matter to produce a change in the state of the moving powers; and a change in the state of the moving powers, produced by other causes, explains every circumstance without the supposition of a morbific matter; and it may be observed, that many of the causes exciting the gout, do not operate upon the state of the fluids, but directly and solely upon that of the moving powers.

Lastly, Dr Cullen contends that the supposition of a morbific matter is superfluous; because, without that, the disease can be explained, he thinks, in a manner more consistent with its phenomena, with the laws of the animal economy, and with the method of cure which experience has approved. We now proceed to give this explanation; but, before entering upon it, we must premise some general observations which Dr Cullen states.

The first observation is, That the gout is a disease of the whole system, or depends upon a certain general conformation and state of the body, which manifestly appears from the facts above mentioned. But the general state of the system depends chiefly upon the state of its primary moving powers; and therefore the gout may be supposed to be an affection of these.

The second observation is, That the gout is manifestly an affection of the nervous system; in which the primary moving powers of the whole system are lodged. The occasional or exciting causes are almost all such as act directly upon the nerves and nervous system; and the greater part of the symptoms of the atonic or retrocedent gout are manifestly affections of the same system. This leads us to seek for an explanation of the whole of the disease, in the laws of the nervous system, and particularly in the changes which may happen in the balance of its several parts.

The third observation is, That the stomach, which has so universal a consent with the rest of the system, is the internal part that is the most frequently, and often very considerably, affected by the gout. The paroxysms of the disease are commonly preceded by an affection of the stomach; many of the exciting causes act first upon the stomach; and the symptoms of the atonic and retrocedent gout are most commonly and chiefly affections of the same organ. This observation leads us to remark, that there is a balance subsisting between the state of the internal and that of the external parts; and, in particular, that the state of the stomach is connected with that of the external parts, so that the state

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state of tone in the one may be communicated to the other.

These observations being premised, Dr Cullen offers the following pathology of the gout.

In some persons there is a certain vigorous and plethoric state of the system, which at a certain period of life is liable to a loss of tone in the extremities. This is in some measure communicated to the whole system, but appears more especially in the functions of the stomach. When this loss of tone occurs while the energy of the brain still retains its vigour, the *vis medicatrix naturæ* is excited to restore the tone of the parts; and accomplishes it, by exciting an inflammatory affection in some part of the extremities. When this has subsisted for some days, the tone of the extremities and of the whole system is restored, and the patient returns to his ordinary state of health.

This is the course of things in the ordinary form of the disease, which we name the *regular gout;* but there are circumstances of the body, in which this course is interrupted or varied. Thus, when the atony has taken place, if the reaction do not succeed, the atony continues in the stomach, or perhaps in other internal parts; and produces that state which Dr Cullen, for reasons now obvious, named the *atonic gout.*

A second case of variation in the course of the gout is, when to the atony the reaction and inflammation have to a certain degree succeeded, but from causes either internal or external the tone of the extremities and perhaps of the whole system is weakened; so that the inflammatory state, before it had either proceeded to the degree, or continued for the time, requisite for restoring the tone of the system, suddenly and entirely ceases: whence the stomach, and other internal parts, relapse into the state of atony; and perhaps have that increased by the atony communicated from the extremities: all which appears in what has been termed the *retrocedent state of the gout.*

A third case of variation from the ordinary course of the gout, is, when to the atony, usually preceding, an inflammatory reaction fully succeeds, but has its usual determination to the joints prevented by some circumstances; and is therefore directed to some internal part, where it produces an inflammatory affection, and that state of things which we have named the *misplaced gout.*

Though this theory of Dr Cullen's be supported with much ingenuity, yet we may confidently venture to assert, that on this subject he has been less successful in establishing his own opinions, than in combating those of others; and this theory, as well as others formerly proposed, is liable to numerous and unsurmountable objections. According to the hypothesis, a vigorous and plethoric habit should in every case exist prior to the appearance of gout; which is by no means consistent with fact: nor is it true that a vigorous and plethoric habit is liable at a certain age to a loss of tone in the extremities; which is another necessary condition in the hypothesis. Loss of tone often occurs in the extremities without exerting any peculiar influence on the stomach; and why a loss of tone in the stomach should excite the *vis medicatrix naturæ* to restore it, by exciting an inflammatory affection in some part of the extremities, is very inconceivable. Were the hypothesis true, every dyspeptic patient should infallibly be affected with gout; which, however, is by no means the case. In short, every step in the theory is liable to unsurmountable objections; and it by no means, any more than former hypotheses, explains the phenomena of the disease, particularly what Dr Cullen has himself so accurately pointed out, the connection of gouty with calculous complaints.

Podag[ra].

A very ingenious work has lately been published by an anonymous author, entitled "A Treatise on Gravel and upon Gout;" in which the sources of each are investigated, and effectual means of preventing or removing these diseases recommended. In this treatise an attempt is made to prove, that both diseases depend upon a peculiar concreting acid, the acid of calculi, or the *lithic* or *uric acid*, as it has been styled by some. He supposes this acid, constantly present to a certain degree in the circulating fluids, to be precipitated by the introduction of other acids; and in this manner he explains the influence of acid wines and other liquors, as claret, cyder, &c. inducing gout; for he considers the circumstance chiefly constituting the disease as being an inflammation in parts of which the functions have been interrupted by the redundant acid precipitated. Although this theory be supported with much ingenuity, yet it is also liable to many objections. The sudden attack of the affection; its sudden transition from one part of the body to another; the instant relief of one part when another comes to be affected; and the various anomalous forms which the disease puts on, having an exact resemblance to different affections; are altogether irreconcileable to the idea of its depending on any fixed obstruction at a particular part arising from concreting acid. Nor does the plan of prevention and cure which he proposes, and which consists chiefly in abstinence from acid, and in the destruction of acid, by any means correspond in every particular to the best established facts respecting the treatment of gout; to which we next proceed.

Cure. In entering upon this, we must observe, in the first place, that a cure has been commonly thought impossible; and we acknowledge it to be very probable, that the gout, as a disease of the whole habit, and very often depending upon original conformation, cannot be cured by medicines, the effects of which are always very transitory, and seldom extend to the producing any considerable change of the whole habit.

It would perhaps have been happy for gouty persons if this opinion had been implicitly received by them; as it would have prevented their having been so often the dupes of self-interested pretenders, who have either amused them with inert medicines, or have rashly employed those of the most pernicious tendency. Dr Cullen, who has treated of the cure of the disease with great judgment, as he has done the theory with much ingenuity, is much disposed to believe the impossibility of the cure of the gout by medicines; and more certainly still inclined to think, that, whatever may be the possible power of medicines, yet no medicine for curing the gout has hitherto been found. Although almost every age has presented a new remedy, all hitherto offered have, very soon after, been either neglected as useless, or condemned as pernicious.

But though unwilling to admit the power of medicines, yet he contends, that a great deal can be done towards

towards the cure of the gout by a regimen: and he is firmly persuaded, that any man who, early in life, will enter upon the constant practice of bodily labour, and of abstinence from animal food, will be preserved entirely from the disease.

Whether there be any other means of radically curing the gout, the Doctor is not able to say. There are histories of cases of the gout, in which it is said, that by great emotions of mind, by wounds, and by other accidents, the symptoms have been suddenly relieved, and never again returned; but how far these accidental cures might be imitated by art, or would succeed in other cases, is at least extremely uncertain.

The practices proper and necessary in the treatment of the gout, are to be considered under two heads: *First*, As they are to be employed in the intervals of paroxysms; or, *secondly*, As during the time of these. In the intervals of paroxysms, the indications are, to prevent altogether the return of paroxysms; or at least to render them less frequent and more moderate. During the time of paroxysms, the indications are, to moderate the violence and shorten the duration of them as much as can be done with safety.

It has been already observed, that the gout may be entirely prevented by constant bodily exercise, and by a low diet; and Dr Cullen is of opinion, that this prevention may take place even in persons who have a hereditary disposition to the disease. Even when the disposition has discovered itself by several paroxysms of inflammatory gout, he is persuaded that labour and abstinence will absolutely prevent any returns of it for the rest of life. These, therefore, are the means of answering the first indication to be pursued in the intervals of paroxysms.

Exercise in persons exposed to the gout, in Dr Cullen's opinion, operates by answering two purposes: One of these is the strengthening of the tone of the extreme vessels; and the other, the guarding against a plethoric state. For the former, if exercise be employed early in life, and before intemperance has weakened the body, a very moderate degree of it will answer the purpose; and, for the latter, if abstinence be at the same time observed, less exercise will be necessary.

With respect to exercise, this in general is to be observed, that it should never be violent; for if violent, it cannot be long continued, and must always endanger the bringing on an atony in proportion to the violence of the preceding motions.

It is also to be observed, that the exercise of gestation, though considerable and constant, will not, if it be entirely without bodily exercise, answer the purpose of preventing the gout. For this end, therefore, the exercise must be in some measure that of the body; and must be moderate, but at the same time constant and continued through life.

In every case and circumstance of the gout in which the patient retains the use of his limbs, bodily exercise, in the intervals of paroxysms, will be always useful; and in the beginning of the disease, when the disposition to it is not yet strong, exercise may prevent a paroxysm which otherwise would have come on. In more advanced states of the disease, however, when there is some disposition to a paroxysm, much walking will bring it on; either as it weakens the tone of the lower extremities, or as it excites an inflammatory disposition in them; and thus it seems to be that sprains or contusions often bring on a paroxysm of the gout.

Abstinence, the other part of the regimen for preventing the gout, is of more difficult application. If an abstinence from animal food be entered upon early in life, while the vigour of the system is yet entire, Dr Cullen has no doubt of its being both safe and effectual; but if the motive for this diet shall not have occurred till the constitution has been broken by intemperance, or by the decline of life, a low diet may then endanger the induction of an atonic state.

Further, If a low diet be entered upon only in the decline of life, and be at the same time a very great change from the former manner of living, the withdrawing of an accustomed stimulus of the system may readily throw it into an atonic state.

The safety of an abstemious course will be greater or less according to the management of it. Animal food especially disposes to the plethoric and inflammatory state, and that food is to be therefore especially avoided; but on the other hand, vegetable aliment of the lowest quality is in danger of weakening the system too much by not affording sufficient nourishment, and more particularly of weakening the tone of the stomach by its acescency. It is therefore a diet of a middle nature that is to be chosen; and milk is precisely of this kind, as containing both animal and vegetable matter.

As approaching to the nature of milk, and as being a vegetable matter containing the greatest portion of nourishment, the farinaceous seeds are next to be chosen, and are the food most proper to be joined with milk.

With respect to drink, fermented liquors are useful only when they are joined with animal food, and that by their acescency; and their stimulus is only necessary from custom. When, therefore, animal food is to be avoided, fermented liquors are unnecessary; and by increasing the acescency of vegetables, these liquors may be hurtful. The stimulus of fermented or spirituous liquors is not necessary to the young and vigorous, and when much employed impairs the tone of the system. These liquors, therefore, are to be avoided, excepting as custom and the declining state of the system may have rendered them necessary. For preventing or moderating the regular gout, water is the only proper drink.

With respect to an abstemious course, it has been supposed, that an abstinence from animal food and fermented liquors, or the living upon milk and farinacea alone for the space of one year, might be sufficient for a radical cure of the gout: and it is possible that, at a certain period of life, in certain circumstances of the constitution, such a measure might answer the purpose. But this is very doubtful: and it is more probable, that the abstinence must, in a great measure, be continued, and the milk diet be persisted in, for the remainder of life. It is well known, that several persons who had entered on an abstemious course, and had been thereby delivered from the gout, have, however, upon returning to their former manner of full living, had the disease return upon them with as much violence

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violence as before, or in a more irregular and more dangerous form.

It has been alleged, that, for preventing the return of the gout, blood-letting or scarifications of the feet, frequently repeated, and at stated times, may be practised with advantage; but of this Dr Cullen tells us he has had no experience; and the benefit of the practice is not, as far as we know, confirmed by the observation of any other practitioner.

Exercise and abstinence are the means of avoiding the plethoric state which gives the disposition to the gout; and are therefore the means proposed for preventing the paroxysms, or at least for rendering them less frequent and more moderate. But many circumstances prevent the steadiness necessary in pursuing these measures; and therefore in such cases, unless great care be taken to avoid the exciting causes, the disease may frequently return, and, in many cases, the preventing of paroxysms is chiefly to be obtained by avoiding those exciting causes already enumerated.

A due attention in avoiding these different causes will certainly prevent fits of the gout; and the taking care that the exciting causes be never applied in a great degree, will certainly render fits more moderate when they do come on. But, upon the whole, it will appear, that a very strict attention to the general conduct of life is in this matter necessary; and therefore, when the predisposition has taken place, it will be extremely difficult to avoid the disease.

Dr Cullen is firmly persuaded, that by obviating the predisposition, and by avoiding the exciting causes, the gout may be entirely prevented: but, as the measures necessary for this purpose will, in most cases, be pursued with difficulty, and even with reluctance, men have been very desirous to find a medicine which might answer the purpose without any restraint on their manner of living. To gratify this desire, physicians have proposed, and, to take advantage of it, empirics have feigned, many remedies. Of what nature several of these remedies have been, it is difficult to say: but of those which are unknown, we conclude, from their having been only of temporary fame, and from their having soon fallen into neglect, that they have been either inert or pernicious. We shall therefore make no inquiry after them; and shall now remark only upon one or two known remedies for the gout which have been lately fashionable.

One of these is what has been named in England the *Portland powder*. This is not a new medicine, but is mentioned by Galen, and, with some little variation in its composition, has been mentioned by the writers of almost every age since that time. It appears to have been at times in fashion, and to have again fallen into neglect; and Dr Cullen thinks that this last has been owing to its having been found to be, in many instances, pernicious. In every instance which he has known of its exhibition for the length of time prescribed, the persons who had taken it were indeed afterwards free from any inflammatory affection of the joints; but they were affected with many symptoms of the atonic gout; and many, soon after finishing their course of the medicine, have been attacked with apoplexy, asthma, or dropsy, which proved fatal.

Another remedy which has had the appearance of preventing the gout, is alkali in various forms; such as the fixed alkali, both mild and caustic, lime water, soap, and absorbent earths; and of late the alkaline aërated water has been more fashionable than any other. Since it became common to exhibit these medicines in nephritic and calculous cases, it has often happened that they were given to those who were at the same time subject to the gout; and it has been observed, that under the use of these medicines, gouty persons have been longer free from the fits of their disease. That, however, the use of these medicines has entirely prevented the returns of gout, Dr Cullen does not know; because he never pushed the use of them for a long time, being apprehensive that the long-continued use of them might produce a hurtful change in the state of the fluids.

Podagra.

As the prevention of gout depends very much on supporting the tone of the stomach, and avoiding indigestion; so costiveness, by occasioning this, is very hurtful to gouty persons. It is therefore necessary for such persons to prevent or remove costiveness, by a laxative medicine, when needful; but it is at the same time proper, that the medicine employed should be such as may keep the belly regular, without much purging. Aloetics, rhubarb, magnesia alba, oleum ricini, or flowers of sulphur, may be employed, as the one or the other may happen to be best suited to particular persons.

These are the several measures to be pursued in the intervals of the paroxysms; and we are next to mention the measures proper during the time of them.

As during the time of paroxysms the body is in a feverish state, no irritation should then be added to it; every part, therefore, of the antiphlogistic regimen, except the application of cold, ought to be strictly observed.

An exception to the general rule, however, may occur when the tone of the stomach is weak, and when the patient has been much more accustomed to the use of strong drink; for then it may be allowable, and even necessary, to give some animal food and a little wine.

That no irritation is to be added to the system during the paroxysms of gout, except in the cases mentioned, is agreed upon among physicians: but it is a more difficult matter to determine, whether, during the time of paroxysms any measures may be pursued to moderate the violence of reaction and of inflammation. Dr Sydenham has given it as his opinion, that the more violent the inflammation and pain, the paroxysm will be the shorter, as well as the interval between the present and the next paroxysm longer; and, if this opinion be admitted as just, it will forbid the use of any remedies which might moderate the inflammation; which is, to a certain degree, undoubtedly necessary for the health of the body. On the other hand, acute pain presses for relief; and although a certain degree of inflammation may seem absolutely necessary, there is reason to believe, a moderate degree of it may answer the purpose; and it is even probable, that in many cases the violence of inflammation may weaken the tone of the parts, and thereby invite a return of paroxysms. It seems to be in this way, that, as the disease advances, the paroxysms become more frequent.

From

From these last considerations, it seems probable, that, during the time of paroxysms some measures may be taken to moderate the violence of the inflammation and pain, and particularly, that in first paroxysms, and in the young and vigorous, blood-letting at the arm may be practised with advantage: but this practice cannot be repeated often with safety; because blood-letting not only weakens the tone of the system, but also contributes to produce plethora. However, bleeding by leeches on the foot, and upon the inflamed part, may be practised and repeated with greater safety; and instances have been known of its having been employed with safety to moderate and shorten paroxysms; but how far it may be carried, we have not had experience enough to determine.

Besides blood-letting and the antiphlogistic regimen, it has been proposed to employ remedies for moderating the inflammatory spasm of the part affected, such as warm bathing and emollient poultices. These have sometimes been employed with advantage and safety; but, at other times, have been found to give occasion to a retrocession of the gout.

Blistering is a very effectual means of relieving and discussing a paroxysm of the gout; but has also frequently had the effect of rendering it retrocedent. The stinging with nettles is analogous to blistering; and probably would be attended with the same danger. The burning with moxa, or other substances, is a remedy of the same kind; but though not found hurtful, there is no sufficient evidence of its proving a radical cure.

Camphor, and some aromatic oils, have the power of allaying the pain, and of removing the inflammation from the part affected: but these remedies commonly make the inflammation only shift from one part to another, and therefore with the hazard of its falling upon a part where it may be more dangerous; and they have sometimes rendered the gout retrocedent.

Among other remedies which have of late been highly extolled during a paroxysm of gout, some have recommended the use of strong purgatives frequently repeated; others have highly extolled the assiduous application of cold water to the affected foot. But we may safely venture to assert that both practices are very doubtful, if not very dangerous.

From these reflections it will appear, that some danger must attend every external application to the parts affected during a paroxysm; and that therefore the common practice of committing the person to patience and flannel alone, is established upon the best foundation. Opiates give the most certain relief from pain; but, when given in the beginning of gouty paroxysms, it has by some been thought that they occasion these to return with greater violence. When, however, the paroxysms shall have abated in their violence, but still continue to return, so as to occasion painful and restless nights, opiates may be given with safety and advantage; especially in the case of persons advanced in life, and who have been often affected with the disease. When, after paroxysms have ceased, some swelling and stiffness still remain in the joints, these symptoms are to be discussed by the diligent use of the flesh-brush. Purging immediately after a paroxysm will be always employed with the hazard of bringing it on again; but keeping the belly gently open even during the continuance of the paroxysm is highly proper.

Thus far of the REGULAR gout. We now proceed to consider the management of the disease when it has become IRREGULAR.

In the *atonic* gout, the cure is to be accomplished by carefully avoiding all debilitating causes; and by employing, at the same time, the means of strengthening the system in general, and the stomach in particular.

For strengthening the system in general, Dr Cullen recommends frequent exercise on horseback, and moderate walking. Cold bathing also may answer the purpose; and may be safely employed, if it appear to be powerful in stimulating the system, and be not applied when the extremities are threatened with any pain.

For supporting the tone of the system in general, when threatened with atonic gout, some animal food ought to be employed, and the more acescent vegetables ought to be avoided. In the same case, some wine also may be necessary; but it should be in moderate quantity, and of the least acescent kinds, and if every kind of wine shall be found to increase the acidity of the stomach, ardent spirits and water must be employed.

For strengthening the stomach, bitters and the Peruvian bark may be used; but care must be taken that they be not constantly employed for any great length of time.

The most effectual medicine for strengthening the stomach is iron, which may be employed under various preparations; but the best appears to be the rust in fine powder, which may be given in large doses.

For supporting the tone of the stomach, aromatics may be exhibited; but should be used with caution, as the frequent and copious use of them has an opposite effect; and they should therefore be given only in compliance with former habits, or for palliating present symptoms.

When the stomach happens to be liable to indigestion, gentle vomits may be frequently given, and proper laxatives should be always employed to obviate or to remove costiveness.

In the atonic gout, or in persons liable to it, to guard against cold is especially necessary; and the most certain means of doing this, is by repairing to a warm climate during the winter season. In the more violent cases, blistering the lower extremities may be useful; but that remedy should be avoided when any pain threatens the extremities. In persons liable to the atonic gout, issues may be established in the extremities as in some measure a supplement to the disease.

A second case of the irregular gout, is the *retrocedent*.

When this affects the stomach and intestines, relief is to be instantly attempted by the free use of strong wines, joined with aromatics, and given warm; or, if these shall not prove powerful enough, ardent spirits must be employed, and are to be given in a large dose. In moderate attacks, ardent spirits, impregnated with garlic or with asafœtida, may be used; or, even without the ardent spirits, a solution of asafœtida with the volatile alkali, may answer the purpose. Opiates are often an effectual remedy; and may be joined

joined with aromatics, as in the electuarium opiatum; or they may be usefully joined with volatile alkali and camphor. Musk has likewise proved useful in this disease.

When the affection of the stomach is accompanied with vomiting, this may be encouraged, by taking draughts of warm water, at first with wine, and afterwards without it; having at length recourse, if necessary, to some of the remedies above mentioned, and particularly the opiates.

In like manner, if the intestines be affected with diarrhœa, this is to be at first encouraged by taking plentifully of weak broth; and when this shall have been done sufficiently, the tumult is to be quieted by opiates.

When the retrocedent gout shall affect the lungs, and produce asthma, this is to be cured by opiates, by antispasmodics, and perhaps by blistering on the back or breast.

When the gout, leaving the extremities, shall affect the head, and produce pain, vertigo, apoplexy, or palsy, our resources are very precarious. The most probable means of relief is, blistering the head; and, if the gout shall have receded very entirely from the extremities, blisters may be applied to these also. Together with these blisterings, aromatics, and the volatile alkali, may be thrown into the stomach.

The third case of the irregular gout is the *misplaced;* that is when the inflammatory affection of the gout, instead of falling upon the extremities, falls upon some internal part. In this case, the disease is to be treated by blood-letting, and by such other remedies as would be proper in an idiopathic inflammation of the same parts.

Whether the translation so frequently made from the extremities to the kidneys, is to be considered as an instance of the misplaced gout, seems uncertain: but Dr Cullen is disposed to think it something different; and therefore is of opinion, that, in the *nephralgia calculosa* produced upon this occasion, the remedies of inflammation are to be employed no farther than they may be sometimes necessary in that disease, arising from other causes than the gout.

Besides what have been mentioned, a variety of other practices may be necessary and proper against the various anomalous symptoms, which are at times produced by irregular gout. But of these we cannot propose to treat. And we may conclude with observing, that in every form of gout, the cure principally depends on avoiding occasional causes, particularly luxury and laziness.

216 GENUS XXV. ARTHROPUOSIS.

Lumbago psoadica, *Sauv.* sp. 6. *Fordyce*, Practice of Physic, part ii. p. 70.
Lumbago apostematosa, *Sauv.* sp. 12.
Lumbago ab arthrocace, *Sauv.* p. 17.
Ischias ex abscessu, *Sauv.* sp. 6.
Morbus coxarius, *De Haen*, Rat. Med. Vol. I. c. xxxii.

This is a disease very much resembling the rheumatism; but differing both from it and the gout, in that it occasions suppurations, which they seldom or never do. It frequently, according to Sauvages, attacks the psoas muscle; and occasions excruciating pains, and then collections of purulent matter.

The only cure, if suppuration cannot be prevented, is to lay open the part where the matter is contained, which would otherwise be absorbed, and occasion a fatal hectic.

ORDER III. EXANTHEMATA. 217

Exanthemata, *Sag.* Class. X.
Phlegmasiæ exanthematicæ, *Sauv.* Class III. Ord. I.
Morbi exanthematici, *Lin.* Class I. Ord. II.
Febres exanthematicæ, *Vog.* Class I. Ord. II.

GENUS XXVI. ERYSIPELAS.

St ANTHONY'S FIRE. 218

Erysipelas, *Sauv.* gen. 97. *Lin.* 10. *Sag.* gen. 296.
Febris erysipelacea, *Vog.* 68. *Hoffm.* II. 98.

Sp. I. ERYSIPELAS with *Blisters.* 219

Erysipelas roseum, *Sauv.* sp. 1. *Sennert. de febr.* lib. ii. c. 15.
Febris erysipelatosa, *Sydenham*, sect. vi. cap. 5.
Erysipelas typhodes, *Sauv.* sp. 2.
Erysipelas pestilens, *Sauv.* sp. 5.
Erysipelas contagiosum, *Sauv.* sp. 9.

Description. The erysipelas of the face, where this affection very frequently appears, comes on with a cold shivering, and other symptoms of pyrexia. The hot stage of this is frequently attended with a confusion of the head, and some degree of delirium; and almost always with drowsiness, and perhaps coma. The pulse is always frequent, and commonly full and hard.—When these symptoms have continued for one, two, or at most three days, an *erythema* appears on some part of the face. This at first is of no great extent, but gradually spreads from the part it first occupied to the other parts of the face, till it has affected the whole; and frequently from the face it spreads over the hairy scalp, or descends on some part of the cheek. As the redness spreads, it commonly leaves, or at least is abated in the parts it had before occupied. All the parts which the redness affects are also affected with some swelling, which continues for some time after the redness has abated. The whole face becomes considerably turgid; and the eyelids are often so much swelled as entirely to shut up the eyes. When the redness and swelling have continued for some time, there commonly arise, sooner or later, blisters of a larger or smaller size on several parts of the face. These contain a thin colourless liquor, which sooner or later runs out. The surface of the skin, in the blistered places, sometimes becomes livid and blackish; but this seldom goes deeper, or discovers any degree of gangrene affecting the cutis vera. On the parts of the face not affected with blisters, the cuticle suffers, towards the end of the disease, a considerable desquamation. Sometimes the tumour of the eyelids ends in a suppuration.

The inflammation coming upon the face does not produce any remission of the fever which had before prevailed; and sometimes the fever increases with the spreading and increasing inflammation. The inflammation

tion commonly continues for eight or ten days; and for the same time, the fever and symptoms attending it also continue. In the progress of the disease, the delirium and coma attending it sometimes go on increasing, and the patient dies apoplectic on the seventh, ninth, or eleventh day of the disease. In such cases it has been commonly supposed, that the disease is translated from the external to the internal parts. But Dr Cullen thinks that the affection of the brain is merely a communication from the external affection, as this continues increasing at the same time with the internal. When a fatal event does not take place, the inflammation, after having affected the whole face, and perhaps the other external parts of the head, ceases, and with that the fever also; and, without any other crisis, the patient returns to his ordinary health. This disease is not commonly contagious; but as it may arise from an acrid matter externally applied, so it is possible that the disease may sometimes be communicated from one person to another; and certainly there are several well authenticated instances of its prevailing in such a manner, even in particular wards of hospitals, as to leave no doubt respecting its contagious nature. Persons who have once laboured under this disease are liable to returns of it.

Prognosis. The event of this disease may be foreseen from the state of the symptoms which denote more or less the affection of the brain. If neither delirium nor coma come on, the disease is seldom attended with any danger; but when these symptoms appear early in the disease, and are in a considerable degree, the utmost danger is to be apprehended.

Cure. The erysipelas of the face is to be cured, according to the opinion of most practitioners, much in the same manner as phlegmonic inflammations; by blood-letting, cooling purgatives, and by employing every part of the antiphlogistic regimen. Many observations, however, would lead us to conclude, that in not a few cases the concomitant fever has here a tendency to the typhoid type; and therefore evacuations, apparently serviceable in the first instance, have afterwards a bad effect. The evacuations of blood-letting and purging are to be employed more or less according to the urgency of symptoms; particularly those which mark an affection of the brain. As the pyrexia continues, and often increases with the inflammation of the face, so the evacuations above mentioned are to be employed at any time of the disease. When, however, the fever, in place of marks of the phlogistic diathesis, particularly a full, hard, and strong pulse, is attended with symptoms of great debility, and with a small pulse easily compressible; evacuations, particularly under the form of blood-letting, must be used with very great caution. Even in such cases, however, the use of refrigerant cathartics may still be persisted in with more safety and greater advantage. But whether evacuants have been employed or not, when symptoms of debility run to a great height, and marks of a putrescent tendency appear, recourse must be had to wine and the cinchona. In cases which at the commencement require evacuation, these are often in the after periods employed with very great benefit.

In this, as in other diseases of the head, when that part happens to be the seat of erysipelas, it is proper to put the patient, as often as he can easily bear it, into somewhat of an erect posture; and as there is always an external affection, so various external applications have been proposed to be made to the part affected; but almost all of them are of doubtful effect.

An erysipelas frequently appears on other parts of the body besides the face, and such other erysipelatous inflammations frequently end in suppuration; but these cases are seldom dangerous. At coming on they are sometimes attended with drowsiness, and even with some delirium; but this seldom happens, and these symptoms do not continue after the inflammation is formed; and Dr Cullen does not remember to have seen an instance of the translation of an inflammation from the limbs to an internal part; and though these inflammations of the limbs be attended with pyrexia, they seldom require the same evacuations as the erysipelas of the face.

Sp. II. Erysipelas with *Phlyctenæ*. 220

Erysipelas zoster, *Sauv.* sp. 8.
Zona; Anglis, *The* Shingles, *Russel* de tab. gland. p. 124. Hist. 35.
Herpes zoster, *Sauv.* sp. 9.

This differs from the former in no other way than in being attended with an eruption of phlyctenæ or small watery bladders on several parts of the body.—The method of cure is the same.

Genus XXVII. PESTIS, the *Plague*. 221

Pestis, *Sauv.* gen. 91. *Lin.* 2. *Junck.* 78.
Febris pestilentialis, *Vog.* 33. *Hoffm.* II. 93.
Pestis benigna, *Sauv.* sp. 2. Pestis Massiliensis, Class III. Traité de la peste, p. 41. Ejusdem pestis, Cl. 5ta, Traité, p. 228.
Pestis remittens, *Sauv.* sp. 9.
Pestis vulgaris, *Sauv.* sp. 1. Pestis Massil. Cl. II. Traité, p. 38. Ejusd. Cl. III. et IV. Traité, p. 225, &c. *Waldschmidt.* de peste Holsatica, apud *Halleri* Diss. Pract. Tom. V. *Chenot.* de peste Transylvanica, 1755, 1759, *De Haen*, Rat. Meds pars xiv.
Pestis Egyptiaca, *Sauv.* sp. 11. *Alpin.* de Med. Egypt.
Pestis interna, *Sauv.* sp. 3. Pest. Massil. Cl. I. Traité, p. 37—224.

History. Of this distemper Dr Cullen declines giving any particular history, because he never saw it; from the accounts of other authors, however, he is of opinion, that the circumstances peculiarly characteristic of it, especially of its more violent and dangerous states, are, 1. The great loss of strength in the animal functions, which often appears early in the disease. 2. The stupor, giddiness, and consequent staggering, which resembles drunkenness, or the headach and various delirium, all of them denoting a great disorder in the functions of the brain. 3. Anxiety, palpitation, syncope, and especially the weakness and irregularity of the pulse, denoting a considerable disturbance in the action of the heart. 4. Nausea and vomiting, particularly the vomiting of bile, which shows an

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an accumulation of vitiated bile in the gall-bladder and biliary ducts, and from thence derived into the intestines and stomach; and which denote a considerable spasm, and loss of tone in the extreme vessels on the surface of the body. 5. The buboes and carbuncles, which denote an acrimony prevailing in the fluids; and, lastly, The petechiæ, hæmorrhages, and colliquative diarrhœa, which denote a putrescent tendency prevailing in a great degree in the mass of blood.

To these characteristics of the plague enumerated by Dr Cullen, we shall add one mentioned by Sir John Pringle, which, though perhaps less frequent than the others, yet seems worthy of notice. It is this, That in the plague there is an extraordinary enlargement of the heart and liver. In nine dissections of bodies dead of the plague at Marseilles, this extraordinary enlargement of the heart is taken notice of in all of them, and of the liver in seven of them. The account was sent to the Royal Society by M. Didier, one of the physicians to the king of France, and has been published in the Philosophical Transactions. In the first case, the author takes notice, that "the heart was of an extraordinary bigness; and the liver was of double the natural size.—Case 2. The heart was of a prodigious bigness, and the liver much enlarged.—Case 3. The heart double the natural bigness.—Case 4. The heart was very large, and the liver was bigger and harder than ordinary.—Case 5. The heart was of a prodigious bigness. Case 6. The heart was larger than in its natural state; the liver also was very large.—Case 7. The heart was of a prodigious size, and the liver was very large.—Case 8. The heart was much larger than natural, and the liver of a prodigious size.—Case 9. The heart was double the natural bigness, and the liver was larger than ordinary."—This preternatural enlargement, Sir J. Pringle thinks, is owing to the relaxation of the solid parts, by which means they become unable to resist the impetus of blood, and therefore are easily extended; as in the case of infancy, where the growth is remarkably quick. And a similar enlargement he takes notice of in the scurvy, and other putrid diseases.

A very elaborate work has lately been published on the subject of the plague by Dr Patrick Russel, formerly physician to the British factory at Aleppo. In this work, a very full history is given of the various forms and varieties of the disease. He makes particular observations on the following symptoms, which, in addition to the pestilential eruptions, he considers as the most important concomitants of plague, viz. fever, delirium, coma, impediment or loss of speech, deafness, muddiness of the eyes, white tongue, state of the pulse, respiration, anxiety, pain at the heart, inquietude, debility, fainting, convulsion, appearances of the urine, perspiration, vomiting, looseness, and hæmorrhage; and he concludes these remarks with some observations on the occurrence of the plague with pregnant women. To point out more distinctly the stable varieties of the disease, he arranges the pestilential cases which fell under his observation at Aleppo under six classes: and he concludes his description with a very minute and particular account of the pestilential eruptions, appearing under the form either of buboes, carbuncles, or other exanthemata. The presence of the two first, he observes, either separately or conjunctly, leaves the nature of the distemper unequivocal. But fatal has been the error of rashly pronouncing a distemper not to be a plague from their absence. Buboes affected the inguinal, axillary, parotid, maxillary, and cervical glands. But the first were the most commonly affected, and the two latter seldom observed to swell, without either the parotid swelling at the time, or soon after. Of the carbuncles, Dr Russel describes five different varieties. The other exanthemata, which he observed sometimes, though less frequently, attending the plague, were petechiæ, a marbled appearance of the skin, an erysipelatous redness, streaks of a reddish purple or livid colour, vibices or weals, and large blue or purple spots, the *maculæ magnæ* of authors. In some cases, an extraordinary concurrence of eruptions took place, which was chiefly observed among children under 10 years of age.

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Causes, &c. From a consideration of the symptoms above mentioned, Dr Cullen concludes, that the plague is owing to a specific contagion, often suddenly producing the most considerable debility in the nervous system, or moving powers, and a general putrescency in the fluids. Dr Russel also considers the disease as being universally the consequence of what may be called *pestilential contagion;* and has judiciously repelled the objections which have been brought against this doctrine.

Prevention. Here we must refer to all those methods of preventing and removing the incipient contagion of putrid fevers, which have been so fully enumerated. Dr Cullen is persuaded that the disease never arises in the northern parts of Europe, but in consequence of being imported from some other country. The magistrate's first care, therefore, ought to be, to prevent the importation; and this may generally be done by a due attention to bills of health, and to the proper performance of quarantines.—With respect to the latter, he is of opinion, that the quarantines of persons may with safety be much less than 40 days; and if this were allowed, the execution of the quarantine would be more exact and certain, as the temptation to break it would be in a great measure avoided. With respect to the quarantine of goods, it cannot be perfect unless the suspected goods be unpacked, duly ventilated, and other means be employed for correcting the infection they may carry; and if all this be properly done, it is probable that the time commonly prescribed for quarantine may also be shortened.

A second measure in the way of prevention is required, when an infection has reached and prevailed in any place, to prevent that infection from spreading into others. This can only be done by preventing the inhabitants or the goods of any infected place from going out of it till they have undergone a proper quarantine.

The third measure, and which ought to be employed with great care, is, to prevent the infection from spreading among the inhabitants of a place in which it has arisen. And in this case, a great deal may be done by the magistrate: 1. By allowing as many of the inhabitants as are free from infection, and are not necessary to the service of the place, to go out of it. 2. By discharging all assemblies, or unnecessary intercourse of the people. 3. By ordering some necessary communications to be performed without contact.

contact. 4. By making such arrangements and provisions as may render it easy for the families remaining to shut themselves up in their own houses. 5. By allowing persons to quit houses where an infection appears, upon condition that they go into lazarettos. 6. By ventilating and purifying, or destroying, at the public expence, all infected goods. 7. By avoiding hospitals, and providing separate apartments for infected persons.

The fourth and last part of the business of prevention respects the conduct of persons necessarily remaining in infected places, especially those obliged to have some communication with persons infected. Those obliged to remain in places infected, but not to have any near communication with the sick, must avoid all near communication with other persons or their goods; and it is probable, that a small distance will serve, if, at the same time, there be no stream of air to carry the effluvia of persons or goods to some distance. Those who are obliged to have a near communication with the sick ought to avoid any of the debilitating causes which render the body susceptible of infection, as a spare diet, intemperance in drinking, excess in venery, cold, fear, or other depressing passions of the mind. A full diet of animal food is also to be avoided, because it increases the irritability of the body, and favours the operation of contagion; and indigestion, whether from the quantity or quality of the food, contributes very much to the same end.

Besides these, it is probable that the moderate use of wine and spirituous liquors, moderate exercise, and the cold bath, may be of use; tonic medicines also, of which cinchona is deservedly accounted the chief, may be used with some probability of success. If any thing is to be expected from antiseptics, Dr Cullen thinks camphor preferable to every other. In general, however, every one is to be indulged in the medicine of which he has the best opinion, provided it is not evidently hurtful. Whether issues be useful in preserving from the effects of contagion, is a matter of doubt. Dr Russel in his treatise enters very fully into the consideration of the means of prevention, both with respect to quarantines, lazarettos, and bills of health. He is of opinion, that the present laws on these subjects are in many respects defective: and he thinks, that a set of new regulations would have the best chance of a deliberate and impartial discussion in the senate, if the inquiry were taken at a time free from all apprehension of immediate danger.

Cure. According to Dr Cullen, the indications are the same as in fever in general, but are not all equally important. The measures for moderating the violence of reaction, which operate by diminishing the action of the heart and arteries, have seldom, he thinks, any place here, excepting that the antiphlogistic regimen is generally proper. Some physicians have recommended bleeding, and Sydenham even seems to think it an effectual cure; but Dr Cullen supposes, that for the most part it is unnecessary, and in many cases might do much hurt. Dr Russel, however, who on this subject speaks from experience and actual observation, is of a different opinion. With most of his patients, a single bleeding was employed with advantage; and even where the sick under his inspection were bled oftener than once, he did not find that the low state was thereby hurried on. Purging has also been recommended; and in some degree it may be useful in drawing off the putrescent matter frequently present in the intestines; but a large evacuation in this way may certainly be hurtful.

The moderating the violence of reaction, as far as it can be done, by taking off the spasm of the extreme vessels, is a measure, in Dr Cullen's opinion, of the utmost necessity in the cure of the plague; and the whole of the means formerly mentioned, as suited to this indication, are extremely proper. The giving an emetic, at the first approach of the disease, would probably be of great service; and it is probable, that, at some other periods of the disease, emetics might be useful, both by evacuating bile abounding in the alimentary canal, and by taking off the spasm of the extreme vessels. Indeed Baron Ash, and some other of the Russian practitioners, represent the early and repeated used of emetics as the only effectual mode of cure.

According to the observations of Dr de Mertens, who wrote a very interesting treatise on the fatal plague which raged at Moscow in 1771, and which carried off upwards of 20,000 inhabitants in the space of one month, emetics were often of the greatest service.

From some principles with respect to fever in general, and with respect to the plague in particular, Dr Cullen is of opinion, that after the exhibition of the first vomit, the body should be disposed to sweat: but this sweat should be raised only to a moderate degree, though it must be continued for 24 hours or more if the patient bears it easily. The sweating is to be excited and conducted according to the rules laid down under SYNOCHA; and must be promoted by the plentiful use of diluents rendered more grateful by vegetable acids, or more powerful by being impregnated with some portion of neutral salts. To support the patient under the continuance of the sweat, a little weak broth, acidulated with the juice of lemons, may be given frequently, and sometimes a little wine if the heat of the body be not considerable. If sudorific medicines be judged necessary, opiates will be found more effectual and safe; but they should not be combined with aromatics, and probably may be more effectual if joined with a portion of emetics and of neutral salts. But if, notwithstanding the use of emetics and sudorifics in the beginning, the disease should still continue, the cure must turn upon the use of means for obviating debility and putrescence; and for this purpose tonic medicines, especially cinchona and cold drink, are the most proper.

GENUS XXVIII. VARIOLA.

The SMALLPOX. 222

Variola, *Sauv.* gen. 92. *Lin.* 3. *Sag.* gen. 290.
Febris variolosa, *Vog.* 35. *Hoffm.* II. 49.
Variolæ, *Boerh.* 1371. *Junck.* 76.

Sp. I. *Distinct SMALLPOX.* 223

Variola discreta benigna, *Sauv.* sp. 2.
Variolæ regulares discretæ, *Sydenh.* sect. iii. cap. 2.

Variolæ

Exanthemata.

Variolæ discretæ simplices, *Helvet.* Obs. sp. 1.
Variola discreta complicata, *Sauv.* sp. 2. *Helvet.* sp. 2.
Variolæ anomalæ, *Sydenh.* sect. iv. cap. 6.
Variola discreta dysenteriodes, *Sauv.* sp. 4. *Sydenh.* sect. iv. cap. 1.
Variola discreta vesicularis, *Sauv.* sp. 5.
Variola discreta crystallina. *Mead* de variol. cap. 2.
Variola discreta verrucosa, *Sauv.* sp. 6. *Mead*, ibid.
Variola discreta siliquosa, *Sauv.* sp. 7. *Freind* Oper. p. 358.
Variola discreta miliaris, *Sauv.* sp. 8. *Helvet.* Obs. sp. 3.

224 Sp. II. *The Confluent* SMALLPOX.

Variola confluens, *Sauv.* sp. 9.
Variolæ regulares confluentes, ann. 1667. *Sydenham*, sect. iii. cap. 2.
Variolæ confluentes simplices, *Helvet.* Obs. sp. 1.
Variola confluens crystallina, *Sauv.* sp. 10.
Variola japonica, *Kempfer.*
Vesiculæ divæ Barbaræ, *C. Pis.* Obs. 149.
Variola confluens maligna, *Helvet.* Obs. sp. 1.
Variola confluens cohærens, *Sauv.* sp. 11.
Variola confluens maligna, *Helvet.* sp. 2.
Variola confluens nigra, *Sauv.* sp. 12. *Sydenham*, sect. v. cap. 4.
Variola confluens maligna, *Helvet.* sp. 3.
Variola sanguinea, *Mead* de variolis, cap. 2.
Variola confluens corymbosa, *Sauv.* sp. 13.
Variola confluens maligna, *Helvet.* sp. 4.

Description. In the distinct smallpox, the disease begins with a synocha or inflammatory fever. This fever generally comes on about mid-day, with some symptoms of a cold stage, and commonly with a considerable languor and drowsiness. A hot stage is soon formed, and becomes more considerable on the second and third day. During this course children are liable to frequent startings from their slumbers; and adults, if they are kept in bed, are disposed to much sweating. On the third day, children are sometimes affected with one or two epileptic fits. Towards the end of the third day the eruption commonly appears, and gradually increases during the fourth; appearing first on the face, and successively on the inferior parts, so as to be completed over the whole body on the fifth day. From the third day the fever abates, and by the fifth it entirely ceases. The eruption appears first in small red spots hardly eminent, but by degrees rising into pimples. There are generally but few on the face; but, even when more numerous, they are separate and distinct from one another. On the fifth or sixth day, a small vesicle, containing an almost colourless fluid, appears on the top of each pimple. For two days these vesicles increase in breadth only, and there is a small hollow pit in their middle, so that they are not raised into spheroidical pustules till the eighth day. These pustules from their first formation continue to be surrounded with an exactly circular inflamed margin, which, when they are numerous, diffuses some inflammation over the neighbouring skin, so as to give somewhat of a damask-rose colour to the spaces between the pustules. As the pustules increase in size, the face swells considerably if they are numerous on it; and the eyelids particularly are so much swelled, that the eyes are entirely shut. As the disease proceeds, the matter in the pustules becomes by degrees more opaque and white, and at length assumes a yellowish colour. On the 11th day the swelling of the face is abated, and the pustules seem quite full. On the top of each a darker spot appears; and at this place the pustule, on the 11th day, or soon after, is spontaneously broken, and a portion of the matter oozes out; in consequence of which the pustule is shrivelled, and subsides; while the matter oozing out dries, and forms a crust upon its surface. Sometimes only a little of the matter oozes out, and what remains in the pustule becomes thick and even hard. After some days, both the crusts and the hardened pustules fall off, leaving the skin which they covered of a brownish red colour; nor doth it resume its natural colour till many days after. In some cases, where the matter of the pustules has been more liquid, the crusts formed from it are later in falling off, and the part they covered suffers some desquamation, which occasions a small hollow or pit.

On the legs and hands the matter is frequently absorbed; so that at the height of the disease, these pustules appear as empty as vesicles. On the 10th and 11th days, as the swelling of the face subsides, a swelling arises in the hands and feet; but which again subsides as the pustules come to maturity.—When the pustules on the face are numerous, some degree of pyrexia appears on the 10th and 11th days; but disappears again after the pustules are fully ripened, or perhaps remains in a very slight degree till the pustules on the feet have finished their course; and it is seldom that any fever continues longer in the distinct smallpox. When the pustules are numerous on the face, upon the sixth or seventh day some uneasiness of the throat, with a hoarseness of the voice, comes on, and a thin liquid is poured out from the mouth. These symptoms increase with the swelling of the face; and the liquids of the mouth and throat becoming thicker, are with difficulty thrown out; and there is at the same time some difficulty in swallowing, so that liquids taken in to be swallowed are frequently rejected or thrown out by the nose. But all these affections of the fauces are abated as the swelling of the face subsides.

In the confluent smallpox all the symptoms above mentioned are much more severe. The eruptive fever particularly is more violent; the pulse is more frequent and more contracted, approaching to that state of pulse which is observed in typhus. The coma is more considerable, and there is frequently a delirium. Vomiting also frequently attends, especially at the beginning of the disease. In very young infants epileptic fits are sometimes frequent on the first days of the disease, and sometimes prove fatal before any eruption appears, or they usher in a very confluent and putrid smallpox. But at the same time, it has been justly remarked by Dr Sydenham, and other accurate observers, that epileptic attacks more frequently precede distinct and mild than malignant and confluent smallpox. The eruption appears in the confluent more early on the third day, and it is frequently preceded or accompanied with an erysipelatous efflorescence. Sometimes

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time the eruption appears in clusters like the measles. When the eruption is completed, the pimples are always more numerous upon the face, and at the same time smaller and less eminent. Upon the eruption the fever suffers some remission, but never goes off entirely; and after the fifth or sixth day it increases again, and continues to be considerable throughout the remaining part of the disease. The vesicles formed on the top of the pimples appear sooner; and while they increase in breadth, they do not retain a circular, but are every way of an irregular figure. Many of them run into one another, insomuch that very often the face is covered with one vesicle rather than with a number of pustules. The vesicles, as far as they are any way separated, do not arise to a spheroidal form, but remain flat, and sometimes the whole of the face appears an even surface. When the pustules are in any measure separated, they are not bounded by an inflamed margin, but the part of the skin that is free from pustules is commonly pale and flaccid. The liquor that is in the pustules changes from a clear to an opaque appearance, and becomes whitish or brownish, but never acquires the yellow colour and thick consistence that appears in the distinct smallpox. The swelling of the face, which only sometimes attends the distinct smallpox, always attends the confluent kind; it also comes on more early, and arises to a greater height, but abates considerably on the tenth or eleventh day. At this time the pustules or vesicles break and shrivel; pouring out at the same time a liquor, which is formed into brown or black crusts, which do not fall off for a long time after. Those of the face, in falling off, leave the skin subject to a desquamation, which pretty certainly produces pittings. On the other parts of the body the pustules of the confluent smallpox are more distinct than on the face; but never acquire the same maturity and consistence of pus as in the properly distinct kind.—The salivation, which sometimes only attends the distinct smallpox, very constantly attends the confluent; and both the salivation and the affection of the fauces above mentioned occur, especially in adults, in a higher degree. In infants a diarrhœa comes frequently in place of a salivation.

In this kind of smallpox there is often a very considerable putrescency of the fluids, as appears from petechiæ, from serous vesicles, under which the skin shows a disposition to gangrene, and from bloody urine or other hæmorrhages; all of which symptoms frequently attend this disease. In the confluent smallpox also, the fever, which had only suffered a remission from the eruption to the maturation, at or immediately after this period is frequently renewed again with considerable violence. This is what has been called the *secondary fever*, and is of various duration and event.

Causes, &c. It is evident that the smallpox is originally produced by a contagion; and that this contagion is a ferment with respect to the fluids of the human body, which assimilates a considerable portion of them to its own nature: or, at least, we have every reason to believe that a small quantity of contagious matter introduced, is sometimes multiplied and increased in the circulating fluids of the animal body. This quantity passes again out of the body, partly by insensible perspiration, and partly by being deposited in pustules: The causes which determine more of the variolous matter to pass by perspiration, or to form pustules, are probably certain circumstances of the skin, which determine more or less of the variolous matter to stick in it, or to pass freely through it. The circumstance of the skin, which seems to determine the variolous matter to stick in it, is a certain state of inflammation depending much on the heat of it: thus we have many instances of parts of the body, from being more heated, having a greater number of pustules than other parts. Thus parts covered with plasters, especially those of the stimulant kind, have more pustules than others.—Certain circumstances also, such as adult age, and full living, determining to a phlogistic diathesis, seem to produce a greater number of pustules, and *vice versa*. It is therefore probable, that an inflammatory state of the whole system, and more particularly of the skin, gives occasion to a greater number of pustules; and the causes of this may produce most of the other circumstances of the confluent smallpox, such as the time of eruption, the continuance of the fever, the effusion of a more putrescent matter, and less fit to be converted into pus, together with the form and other circumstances of the pustules.

Prognosis. The more exactly the disease retains the form of the distinct kind, it is the safer; and the more completely the disease takes the form of the confluent kind, it is the more dangerous. It is only when the distinct kind shows a great number of pustules on the face, or otherwise by fever or putrescency, approaching to the circumstances of the confluent, that the distinct kind is attended with any danger.

In the confluent kind the danger is always very considerable; and the more violent and permanent the fever is, the greater the danger; and especially in proportion to the increase of the symptoms of putrescency. When the putrid disposition is very great, the disease sometimes proves fatal before the eighth day; but in most cases death happens on the eleventh, and sometimes not till the fourteenth or seventeenth day.

Though the smallpox may not prove immediately fatal, the more violent kinds are often followed by a morbid state of the body, sometimes of very dangerous event. These consequences, according to Dr Cullen, may be imputed sometimes to an acrid matter produced by the preceding disease, and deposited in different parts; and sometimes to an inflammatory diathesis produced and determined to particular parts of the body.

Since the introduction of smallpox into Europe, there is perhaps no disease which has produced a greater number of deaths. But, fortunately, a discovery is now made, by which there is reason to hope that this loathsome disease may be altogether exterminated; its prevention, viz. by the inoculation of the vaccine or cowpox.

This most important discovery we owe to the successful exertions of Dr Edward Jenner; to whom, for these exertions, repeated rewards have been voted by the British legislature, but who unquestionably enjoys a much higher reward in the satisfaction of having conferred an inestimable blessing on the human species.

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For an account of the progress of this discovery, we must refer our readers to Dr Jenner's publication. Here we shall only observe, that it had long been remarked in some parts of England, particularly in the neighbourhood of Berkley, where Dr Jenner resided, that cows were liable to a pustular disease on their udders, somewhat resembling smallpox; that this disease was communicated by contact to the fingers of those employed in milking the cows; and, finally, that those thus infected with cowpox, were completely protected against the contagion of smallpox.

Founding on these observations, Dr Jenner ascertained by experiment, that the inoculation of vaccine matter was an infallible preventive of smallpox; and that this vaccine matter had equal power in preventing variola when transferred from one human subject to another, as when obtained immediately from the cow. It is not therefore wonderful that this practice of vaccine inoculation should soon have become general, both in Britain and in every quarter of the world. Nor is it perhaps surprising, that it should have been violently opposed by ignorant and obstinate men. Hence numerous publications have of late appeared both for and against this practice. Many mistakes have undoubtedly been committed by ignorance and inattention; and thus the preventive has been supposed to fail. For the best account both of the method of performing the operation, of conveying the vaccine matter from one place to another, and of the tests of constitutional affection in those cases in which the inflammation is slight, and in which no fever is perceptible, we may refer our readers to a treatise published at Edinburgh in 1802, by Mr James Bryce, entitled Practical Observations on the Inoculation of Cowpox.

Of the efficacy of vaccine inoculation as a preventive of smallpox, few candid men will entertain any doubt, after the following report on vaccination, from the Royal College of Physicians in London, ordered to be printed on the 8th of July 1807, by the British parliament.

REPORT, &c.

The Royal College of Physicians of London, having received his majesty's commands in compliance with an address from the house of commons, "to inquire into the state of vaccine inoculation in the united kingdom, to report their opinion and observations upon that practice, upon the evidence which has been adduced in its support, and upon the causes which have hitherto retarded its general adoption;—have applied themselves diligently to the business referred to them.

Deeply impressed with the importance of an inquiry which equally involves the lives of individuals, and the public prosperity, they have made every exertion to investigate the subject fully and impartially. In aid of the knowledge and experience of the members of their own body, they have applied separately to each of the licentiates of the college; they have corresponded with the colleges of physicians of Dublin and Edinburgh; with the colleges of surgeons of London, Edinburgh, and Dublin; they have called upon the societies established for vaccination, for an account of their practice, to what extent it has been carried on, and what has been the result of their experience; and they have, by public notice, invited individuals to contribute whatever information they had severally collected. They have in consequence been furnished with a mass of evidence communicated with the greatest readiness and candour, which enables them to speak with confidence upon all the principal points referred to them.

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I. During eight years which have elapsed since Dr Jenner made his discovery public, the progress of vaccination has been rapid, not only in all parts of the united kingdom, but in every quarter of the civilized world. In the British islands some hundred thousands have been vaccinated, in our possessions in the East Indies upwards of 800,000, and among the nations of Europe the practice has become general. Professional men have submitted it to the fairest trials, and the public have, for the most part, received it without prejudice. A few indeed have stood forth the adversaries of vaccination, on the same grounds as their predecessors who opposed the inoculation for the smallpox, falsely led by hypothetical reasoning in the investigation of a subject which must be supported, or rejected, upon facts and observation only. With these few exceptions, the testimony in favour of vaccination has been most strong and satisfactory, and the practice of it, though it has received a check in some quarters, appears still to be upon the increase in most parts of the united kingdom.

II. The college of physicians, in giving their observations and opinions on the practice of vaccination, think it right to premise, that they advance nothing but what is supported by the multiplied and unequivocal evidence which has been brought before them, and they have not considered any facts as proved but what have been stated from actual observation.

Vaccination appears to be in general perfectly safe: the instances to the contrary being extremely rare. The disease excited by it is slight, and seldom prevents those under it from following their ordinary occupations. It has been communicated with safety to pregnant women, to children during dentition, and in their earliest infancy; in all which respects it possesses material advantages over inoculation for the smallpox; which though productive of a disease generally mild, yet sometimes occasions alarming symptoms, and is in a few cases fatal.

The security derived from vaccination against the smallpox, if not absolutely perfect, is as nearly so as can perhaps be expected from any human discovery; for amongst several hundred thousand cases, with the results of which the college have been made acquainted, the number of alleged failures has been surprisingly small, so much so, as to form certainly no reasonable objection to the general adoption of vaccination; for it appears that there are not nearly so many failures, in a given number of vaccinated persons, as there are deaths in an equal number of persons inoculated for the smallpox. Nothing can more clearly demonstrate the superiority of vaccination over the inoculation of the smallpox, than this consideration; and it is a most important fact, which has been confirmed in the course of this inquiry, that in almost every case, where the smallpox has succeeded vaccination, whether by inoculation or by casual infection, the disease has varied much from its ordinary course; it has neither been the same in the violence, nor in the duration of its symptoms, but has, with

with very few exceptions, been remarkably mild, as if the smallpox had been deprived, by the previous vaccine disease, of all its usual malignity.

The testimonies before the college of physicians are very decided in declaring, that vaccination does less mischief to the constitution, and less frequently gives rise to other diseases, than the smallpox, either natural or inoculated.

The college feel themselves called upon to state this strongly, because it has been objected to vaccination, that it produces new, unheard-of, and monstrous diseases. Of such assertions no proofs have been produced, and, after diligent inquiry, the college believe them to have been either the inventions of designing, or the mistakes of ignorant men. In these respects then, in its mildness, its safety, and its consequences, the individual may look for the peculiar advantages of vaccination. The benefits which flow from it to society are infinitely more considerable, it spreads no infection, and can be communicated only by inoculation. It is from a consideration of the pernicious effects of the smallpox, that the real value of vaccination is to be estimated. The natural smallpox has been supposed to destroy a sixth part of all whom it attacks; and that even by inoculation, where that has been general in parishes and towns, about one in 300 has usually died. It is not sufficiently known, or not adverted to, that nearly one-tenth, some years more than one-tenth of the whole mortality in London, is occasioned by the smallpox; and however beneficial the inoculation of the smallpox may have been to individuals, it appears to have kept up a constant source of contagion, which has been the means of increasing the number of deaths by what is called the natural disease. It cannot be doubted that this mischief has been extended by the inconsiderate manner in which great numbers of persons, even since the introduction of vaccination, are still every year inoculated with the smallpox, and afterwards required to attend two or three times a-week at the places of inoculation, through every stage of their illness.

From this, then, the public are to expect the great and uncontroverted superiority of vaccination, that it communicates no casual infection, and, while it is a protection to the individual, it is not prejudicial to the public.

III. The college of physicians, in reporting their observations and opinions on the evidence adduced in support of vaccination, feel themselves authorised to state that a body of evidence so large, so temperate, and so consistent, was perhaps never before collected upon any medical question. A discovery so novel, and to which there was nothing analogous known in nature, though resting on the experimental observations of the inventor, was at first received with diffidence: it was not, however, difficult for others to repeat his experiments, by which the truth of his observations was confirmed, and the doubts of the cautious were gradually dispelled by extensive experience. At the commencement of the practice, almost all that were vaccinated were afterwards submitted to the inoculation of the smallpox; many underwent this operation a second, and even a third time, and the uniform success of these trials quickly bred confidence in the new discovery. But the evidence of the security derived from vaccination against the smallpox does not rest alone upon those who afterwards underwent variolous inoculation, although amounting to many thousands; for it appears, from numerous observations communicated to the college, that those who have been vaccinated are equally secure against the contagion of epidemic smallpox. Towns, indeed, and districts of the country in which vaccination had been general, have afterwards had the smallpox prevalent on all sides of them without suffering from the contagion. There are also in the evidence a few examples of epidemic smallpox having been subdued by a general vaccination. It will not, therefore, appear extraordinary that many who have communicated their observations should state, that though at first they thought unfavourably of the practice, experience had now removed all their doubts.

It has been already mentioned, that the evidence is not universally favourable, although it is in truth nearly so, for there are a few who entertain sentiments differing widely from those of the great majority of their brethren. The college, therefore, deemed it their duty, in a particular manner, to inquire upon what grounds and evidence the opposers of vaccination rested their opinions. From personal examination, as well as from their writings, they endeavoured to learn the full extent and weight of their objections. They found them without experience in vaccination, supporting their opinions by hearsay information and hypothetical reasoning; and, upon investigating the facts which they advanced, they found them to be either misapprehended or misrepresented; or that they fell under the description of cases of imperfect smallpox, before noticed, and which the college have endeavoured fairly to appreciate.

The practice of vaccination is but of eight years standing, and its promoters, as well as opponents, must keep in mind, that a period so short is too limited to ascertain every point, or to bring the art to that perfection of which it may be capable. The truth of this will readily be admitted by those acquainted with the history of inoculation for the smallpox. Vaccination is now, however, well understood, and its character accurately described. Some deviations from the usual course have occasionally occurred, which the author of the practice has called spurious cowpox, by which the public have been misled, as if there were a true and a false cowpox; but it appears, that nothing more was meant, than to express irregularity or difference from that common form and progress of the vaccine pustule from which its efficacy is inferred. Those who perform vaccination ought therefore to be well instructed, and should have watched with the greatest care the regular progress of the pustule, and learnt the most proper time for taking the matter. There is little doubt that some of the failures are to be imputed to the inexperience of the early vaccinators, and it is not unreasonable to expect that farther observation will yet suggest many improvements that will reduce the number of anomalous cases, and furnish the means of determining, with greater precision, when the vaccine disease has been effectually received.

Though the college of physicians have confined themselves in estimating the evidence to such facts as have occurred in their own country, because the accuracy of them could best be ascertained, they cannot be insensi-

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ble to the confirmation these receive from the reports of the successful introduction of vaccination, not only into every part of Europe, but throughout the vast continents of Asia and America.

IV. Several causes have had a partial operation in retarding the general adoption of vaccination; some writers have greatly undervalued the security it affords, while others have considered it to be of a temporary nature only; but if any reliance is to be placed on the statements which have been laid before the college, its power of protecting the human body from the smallpox, though not perfect indeed, is abundantly sufficient to recommend it to the prudent and dispassionate, especially as the smallpox, in the few instances where it has subsequently occurred, has been generally mild and transient. The opinion that vaccination affords but a temporary security is supported by no analogy in nature, nor by the facts which have hitherto occurred. Although the experience of vaccine inoculation be only of a few years, yet the same disease, contracted by the milkers of cows in some districts, has been long enough known, to ascertain that, in them at least, the unsusceptibility of the smallpox contagion does not wear out by time.

Another cause, is the charge against vaccination of producing various new diseases of frightful and monstrous appearance. Representations of some of these have been exhibited in prints in a way to alarm the feelings of parents, and to infuse dread and apprehension into the minds of the uninformed. Publications with such representations have been widely circulated, and though they originate either in gross ignorance, or wilful misrepresentation, yet they have lessened the confidence of many, particularly of the lower classes, in vaccination; no permanent effects, however, in retarding the progress of vaccination, need be apprehended from such causes, for, as soon as the public shall view them coolly and without surprise, they will excite contempt, and not fear.

Though the college of physicians are of opinion that the progress of vaccination has been retarded in a few places by the above causes, yet they conceive that its general adoption has been prevented by causes far more powerful, and of a nature wholly different. The lower orders of society can hardly be induced to adopt precautions against evils which may be at a distance; nor can it be expected from them, if these precautions are attended with expence. Unless, therefore, from the immediate dread of epidemic smallpox, neither vaccination nor inoculation appear at any time to have been general, and when the cause of terror has passed by, the public have relapsed again into a state of indifference and apathy, and the salutary practice has come to a stand. It is not easy to suggest a remedy for an evil so deeply imprinted in human nature. To inform and instruct the public mind may do much, and it will probably be found that the progress of vaccination in different parts of the united kingdom will be in proportion to that instruction. Were encouragement given to vaccination, by offering it to the poorer classes without expence, there is little doubt but it would in time supersede the inoculation for the smallpox, and thereby various sources of variolous infection would be cut off; but till vaccination becomes general, it will be impossible to prevent the constant recurrence of the natural smallpox by means of those who are inoculated, except

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it should appear proper to the legislature to adopt, in its wisdom, some measure by which those who still, from terror or prejudice, prefer the smallpox to the vaccine disease, may, in thus consulting the gratification of their own feelings, be prevented from doing mischief to their neighbours.

From the whole of the above considerations, the college of physicians feel it their duty strongly to recommend the practice of vaccination. They have been led to this conclusion by no preconceived opinion, but by the most unbiassed judgment, formed from an irresistible weight of evidence which has been laid before them. For when the number, the respectability, the disinterestedness, and the extensive experience of its advocates, is compared with the feeble and imperfect testimonies of its few opposers; and when it is considered that many, who were once adverse to vaccination, have been convinced by further trials, and are now to be ranked among its warmest supporters, the truth seems to be established as firmly as the nature of such a question admits; so that the college of physicians conceive that the public may reasonably look forward with some degree of hope to the time when all opposition shall cease, and the general concurrence of mankind shall at length be able to put an end to the ravages at least, if not to the existence, of the smallpox.

LUCAS PEPYS, PRESIDENT.

Royal College of Physicians, 10th of April, 1807.

JA. HERVEY, *Register.*

APPENDIX.

N° I.

To the Royal College of PHYSICIANS *of London.*

GENTLEMEN,

I am ordered by the King and Queen's College of Physicians, in Ireland, to thank the Royal College of Physicians of London for the communication they have had the honour to receive from them, of certain propositions relative to vaccination, whereon his majesty has been pleased to direct an enquiry to be instituted, and in the prosecution of which, the co-operation of the college in Ireland is requested.

And I am directed to acquaint you, that the said college having referred the investigations of these propositions to a committee, have received from them a report, of which the inclosed is a copy; and that they desire the same may be considered as containing their opinion upon the subject.

I have the honour to be,

Gentlemen,

Your most obedient humble servant,

By order of the King and Queen's College of Physicians in Ireland.

HUGH FERGUSON, *Register.*

Dublin, 11th *Nov.* 1806.

" The practice of vaccination was introduced into this

this city about the beginning of the year 1801, and appears to have made inconsiderahle progress at first. A variety of causes operated to retard its general adoption, amongst which the novelty of the practice, and the extraordinary effects attributed to vaccination, would naturally take the lead.

"Variolous inoculation had heen long, almost exclusively, in the hands of a particular branch of the profession, whose prejudices and interests were strongly opposed to the new practice; and by their being the usual medical attendants in families, and especially employed in the diseases of children, their opinions had greater effect upon the minds of parents. The smallpox is rendered a much less formidable disease in this country by the frequency of inoculation for it, than it is in other parts of his majesty's dominions, where prejudices against inoculation have prevailed; hence parents, not unnaturally, objected to the introduction of a new disease, rather than not recur to that, with the mildness and safety of which they were well acquainted.

"In the beginning of the year 1804, the cowpox institution was established under the patronage of the earl of Hardwicke, and it is from this period that we may date the general introduction of vaccination into this city, and throughout all parts of Ireland.

"The success of the institution, in forwarding the new practice, is to be attributed in a great measure to the respectability of the gentlemen who superintended it, and to the diligence, zeal, and attention of Dr Labatt, their secretary and inoculator. In order to shew the progress which has been made in extending vaccination, your committee refer to the reports of the Cowpox Institution for the last two years, and to extracts from their register for the present year.

	Patients Inoculated.	*Packets issued to Practitioners in general.*	*Packets to Army Surgeons.*
1804	578	776	236
1805	1032	1124	178
1806	1356	1340	220
Total	2966	3240	634

"In the above statement, the numbers are averaged to the end of the present year, on the supposition of patients resorting to the institution as usual. The correspondence of the institution appears to be very general throughout every part of Ireland, and by the accounts received, as well from medical practitioners as others, the success of vaccination seems to be uniform and effectual. At the present period, in the opinion of your committee, there are few individuals in any branch of the profession, who oppose the practice of vaccination in this part of his majesty's dominions.

"It is the opinion of your committee, that the practice of cowpox inoculation is safe, and that it fully answers all the purposes that have been intended by its introduction. At the same time, your committee is willing to allow that douhtful cases have been reported to them as having occurred, of persons suffering from smallpox, who have been previously vaccinated. Upon minute investigation, however, it has been found, that these supposed instances originated generally in error, misrepresentation, or the difficulty of discriminating between smallpox and other eruptions, no case having come to the knowledge of your committee, duly authenticated by respectable and competent judges, of genuine smallpox succeeding the regular vaccine disease.

"The practice of vaccination becomes every day more extended; and, when it is considered that the period at which it came into general use in Ireland is to be reckoned from so late a date, your committee is of opinion, that it has made already as rapid a progress as could be expected.

(Signed) "JAMES CLEGHORN.
"DANIEL MILLS.
"HUGH FERGUSON."

N° II.

Physicians Hall, Edinburgh 26th Nov. 1806.

GENTLEMEN,

THE Royal College of Physicians of Edinburgh have but little opportunity themselves of making ohservations on vaccination, as that practice is entirely conducted by surgeon apothecaries, and other medical practitioners not of their college, and as the effects produced by it are so inconsiderahle and slight, that the aid of a physician is never required.

The College know that in Edinburgh it is universally approved of hy the profession, and by the higher and middle ranks of the community; and that it has been much more generally adopted hy the lower orders of the people than ever the inoculation for smallpox was, and they believe the same to obtain all over Scotland.

With regard to any causes which have hitherto prevented its general adoption, they are acquainted with none except the negligence or ignorance of parents among the common people, or their mistaken ideas of the impropriety or criminality of being accessary to the production of any disease among their children, or the difficulty or impossibility, in some of our country districts, of procuring vaccine matter, or a proper person to inoculate.

The evidence in favour of vaccination appeared to the Royal College of Physicians of Edinhurgh so strong and decisive, that in May last, they spontaneously and unanimously elected Dr Jenner an honorary fellow of their college;—a mark of distinction which they very rarely confer, and which they confine almost exclusively to foreign physicians of the first eminence.

They did this with a view to publish their opinion with regard to vaccination, and in testimony of their conviction of the immense benefits which have been, and which will in future be derived to the world, from inoculation for the cowpox, and as a mark of their sense of Dr Jenner's very great merits and ability in introducing and promoting this invaluable practice.

I have the honour to be,
Gentlemen,
Your most obedient humhle servant,
TH. SPENS, *C. R. M. Ed. Pr.*

To the Royal College of
Physicians of London.

N° III.

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N° III.

At a special court of assistants of the Royal College of Surgeons, convened by order of the Master, and holden at the College on Tuesday the 17th day of March 1807;

Mr Governor Lucas in the chair:

Mr Long, as chairman of the board of curators, reported, that the board are now ready to deliver their report on the subject of vaccination.

It was then moved, seconded, and resolved, that a report from the board of curators, on the subject of vaccination, which was referred to their consideration by the court of assistants, on the 21st day of November last, be now received.

Mr Long then delivered to Mr Governor Lucas (presiding in the absence of the master) a report from the board of curators.

It was then moved, seconded, and resolved, that the report, delivered by Mr Long, be now read; and it was read accordingly, and is as follows.

To the Court of Assistants of the Royal College of Surgeons in London.

THE report of the Board of Curators, on the subject of vaccination, referred to them by the court, on the 21st day of November 1806; made to the court on the 17th of March 1807.

THE court of assistants having received a letter from the Royal College of Physicians of London, addressed to this college, stating, that his majesty had been graciously pleased, in compliance with an address from the honourable House of Commons, to direct his Royal College of Physicians of London to enquire into the state of vaccination in the united kingdom, to report their observations and opinion upon that practice, upon the evidence adduced in its support, and upon the causes which have hitherto retarded its general adoption; that the college were then engaged in the investigation of the several propositions thus referred to them, and requesting this college to co-operate and communicate with them, in order that the report thereupon might be made as complete as possible.

And having, on the 21st day of November last, referred such letter to the consideration of the board of curators, with authority to take such steps respecting the contents thereof as they should judge proper, and report their proceedings thereon, from time to time, to the court: the board proceeded with all possible dispatch to the consideration of the subject.

The board being of opinion, that it would be proper to address circular letters to the members of this college, with a view of collecting evidence, they submitted to the consideration of the court, holden on the 15th day of December last, the drafts of such letter as appeared to them best calculated to answer that end; and the same having been approved by the court, they caused copies thereof to be sent to all the members of the college in the united kingdom, whose residence could be ascertained, in the following form; viz.

"Sir,

"The Royal College of Surgeons being desirous to co-operate with the Royal College of Physicians of London, in obtaining information respecting vaccination, submit to you the following questions, to which the favour of your answer is requested.

"By order of the Court of Assistants,
OKEY BELFOUR, *Secretary*."

Lincoln's-Inn-Fields,
Dec. 15. 1806.

"1st, How many persons have you vaccinated?

"2d, Have any of your patients had the smallpox after vaccination? In the case of every such occurrence, at what period was the vaccine matter taken from the vesicle? How was it preserved? How long before it was inserted? What was the appearance of the inflammation? And what the interval between vaccination and the variolous eruption?

"3d, Have any bad effects occurred in your experience in consequence of vaccination? And if so, what were they?

"4th, Is the practice of vaccination increasing or decreasing in your neighbourhood? If decreasing, to what cause do you impute it?"

To such letters the board have received 426 answers: and the following are the results of their investigation:

The number of persons, stated in such letters to have been vaccinated, is 164,381.

The number of cases in which smallpox had followed vaccination is 56.

The board think it proper to remark under this head, that, in the enumeration of cases in which smallpox has succeeded vaccination, they have included none but those in which the subject was vaccinated by the surgeon reporting the facts.

The bad consequences which have arisen from vaccination are, eruptions of the skin in 66 cases, and inflammation of the arm in 24 instances, of which three proved fatal.

Vaccination, in the greater number of counties from which reports have been received, appears to be increasing; it may be proper, however, to remark, that, in the metropolis, it is on the decrease.

The principal reasons assigned for the decrease are,

Imperfect vaccination.
Instances of smallpox after vaccination.
Supposed bad consequences.
Publications against the practice.
Popular prejudices.

And such report having been considered, it was moved, seconded, and

Resolved, That the report now read be adopted by this court, as the answer of the court to the letter of the Royal College of Physicians, of the 23d day of October last, on the subject of vaccination.

Resolved, That a copy of these minutes and resolutions, signed by Mr Governor Lucas (presiding at this court in the presence of the master) be transmitted by the secretary to the register of the Royal College of Physicians.

(Signed) WM. LUCAS.

N° IV.

N° IV.

Sir, *Edinburgh, March* 3. 1807.

I mentioned in my former letter, that I would take the earliest opportunity of laying before the Royal College of Surgeons of Edinburgh, the communication with which the Royal College of Physicians of London had honoured them, on the 23d of October last:

I am now directed by the Royal College to send the following answer on that important subject.

The practice of vaccine inoculation, both in private, and at the vaccine institution established here in 1801, is increasing so rapidly, that for two or three years past, the smallpox has been reckoned rather a rare occurrence, even among the lower orders of the inhabitants of this city, unless in some particular quarters about twelve months ago; and, among the higher ranks of the inhabitants, the disease is unknown.

The members of the Royal College of Surgeons have much pleasure in reporting, that, as far as their experience goes, they have no doubt of the permanent security against the smallpox which is produced by the constitutional affection of the cowpox; and that such has hitherto been their success in vaccination, as also to gain for it the confidence of the public, insomuch that they have not been required, for some years past, to inoculate any person with smallpox who had not previously undergone the inoculation with the cowpox.

The members of the Royal College have met with no occurrence in their practice of cowpox inoculation, which could operate in their minds to its disadvantage; and they beg leave particularly to notice, that they have seen no instance of obstinate eruptions, or of new and dangerous diseases, which they could attribute to the introduction among mankind of this mild preventive of smallpox. The Royal College of Surgeons know of no causes which have hitherto retarded the adoption of vaccine inoculation here; on the contrary, the practice has become general within this city; and from many thousand packets of vaccine matter having been sent by the members of the Royal College, and the vaccine institution here, to all parts of the country, the Royal College have reason to believe that the practice has been as generally adopted throughout this part of the united kingdom as could have been expected from the distance of some parts of the country from proper medical assistance, and other circumstances of that nature.

I have the honour to be,
Sir,
Your most obedient servant,
WM. FARQUHARSON,

President of the Royal College and Incorporation of Surgeons of Edinburgh.

N° V.

Royal College of Surgeons in Ireland,
Sir, *Dublin, February 4th,* 1807.

I am directed to transmit to you the inclosed report of a committee of the College of Surgeons in Ireland, to whom was referred a letter from the Royal College of Physicians in London, relative to the present state of vaccination in this part of the united kingdom; and to state, that the College of Surgeons will be highly gratified by more frequent opportunities of corresponding with the English College of Physicians on any subject which may conduce to the advancement of science, and the welfare of the public.

I have the honour to be,
Sir,
Your most obedient humble servant,
JAMES HENTHORN, *Secretary.*

At a meeting of the Royal College of Surgeons in Ireland, holden at their Theatre, on Tuesday the 13th day of January 1807.

FRANCIS M'EVOY, ESQ. *President.*

Mr Johnson reported from the committee, to whom was referred a letter from the College of Physicians, London, relative to the present state of vaccination in the united kingdom, &c. &c. that they met, and came to the following resolutions:

That it appears to this committee, That inoculation with vaccine infection is now very generally adopted by the surgical practitioners in this part of the united kingdom, as a preventive of smallpox.

That it appears to this committee, that from the 25th day of March 1800 to the 25th of November 1806, 11,504 persons have been inoculated with vaccine infection at the dispensary for infant poor, and 2831 at the cowpox institution, making a total of 14,335, exclusive of the number inoculated at hospitals and other places, where no registry is made and preserved.

That it is the opinion of this committee, that the cowpox has been found to be a mild disease, and rarely attended with danger, or any alarming symptom, and that the few cases of smallpox which have occurred in this country, after supposed vaccination, have been satisfactorily proved to have arisen from accidental circumstances, and cannot be attributed to the want of efficacy in the genuine vaccine infection as a preventive of smallpox.

That it is the opinion of this committee, that the causes which have hitherto retarded the more general adoption of vaccination in Ireland, have, in a great measure, proceeded from the prejudices of the lower classes of the people, and the interest of some irregular practitioners.

To which report the College agreed.

Extract from the minutes,
JAMES HENTHORN, *Secretary.*

After this report, we cannot help thinking that the British legislature would be fully warranted for passing an act prohibiting the inoculation of smallpox under very severe penalties, and ordering all those who may be subjected to smallpox by accidental contagion to be confined to lazarettos, or at least to their own houses, under a proper guard, to prevent the communication of infection, till their complete recovery. By such an act, there is good ground to believe, that the loathsome and dangerous disease of smallpox would in a few years be exterminated in Britain.

But

Exanthemata.

But although providence has thus furnished mankind with an easy mode of preserving their offspring from the danger of smallpox, by the inoculation of the cowpox at an early period of life, yet not a few deaths from the natural small-pox have occurred in Britain even during the course of the present year.

When the preventive has not been duly employed, after the contagion of variola is introduced into the body, nothing yet known will prevent the disease from running its course, either under the mild or confluent form; and the endeavours of the medical practitioner are altogether to be employed in rendering that course as favourable as possible by mitigating symptoms.

In the mild or distinct smallpox, the strictest antiphlogistic regimen is to be enjoined. Gentle refrigerant cathartics are often useful, and mild diluents should be copiously employed. Under these remedies the disease will generally run its course without much inconvenience. But it will sometimes be necessary to employ remedies for obviating particular urgent symptoms, such as gargarisms or blisters for affections of the throat.

In the malignant smallpox, besides the same refrigerant plan of cure which is best accommodated to the mild, as the secondary fever shows evident marks of a putrid tendency, it is necessary to employ those remedies which are accommodated to typhus, and accordingly recourse is not only had to opiates and cardiacs, but to wine, cinchona, and the mineral acids.

Genus XXIX. VARICELLA.

26 *Chickenpox.*

Varicella, *Vog.* 42.
Variola lymphatica, *Sauv.* sp. 1.
Anglis *The Chickenpox*, Edin. Med. Essays, vol. ii. art. 2. near the end. *Heberden*, Med. Transac. art. 17. *The Watery-Pox.*

This is in general a very slight disease; and it is attended with so little danger, that it would not merit any notice, if it were not apt to be confounded with the smallpox, and thus give occasion to an opinion that a person might have the smallpox twice in his life; or they are apt to deceive into a false security those who have never had the smallpox, and make them believe that they are safe when in reality they are not. This eruption breaks out in many, according to Dr Heberden, without any illness or previous sign; in others it is preceded by a slight degree of chilness, lassitude, cough, broken sleep, wandering pains, loss of appetite, and feverish state for three days.

In some patients the chicken-pox make their first appearance on the back; but this perhaps is not constant. Most of them are of the common size of the small-pox, but some are less. Dr Heberden never saw them confluent, nor very numerous. The greatest number was about 12 on the face, and 200 over the rest of the body.

On the first day of the eruption they are reddish. On the second day there is at the top of most of them a very small bladder, about the size of a millet seed. This is sometimes full of a watery and colourless, sometimes of a yellowish liquor, contained between the cuticle and skin. On the second, or, at the farthest, on the third day from the beginning of the eruption, as many of these pocks as are not broken seem arrived at their full maturity; and those which are fullest of that yellow liquor very much resemble what the genuine smallpox are on the fifth or sixth day, especially where there happens to be a larger space than ordinary occupied by the extravasated serum. It happens to most of them, either on the first day that this little bladder arises, or on the day after, that its tender cuticle is burst by the accidental rubbing of the clothes, or by the patient's hands to allay the itching which attends this eruption. A thin scab is then formed at the top of the pock, and the swelling of the other part abates, without its ever being turned into pus, as it is in the smallpox. Some few escape being burst; and the little drop of liquor contained in the vesicle at the top of them, grows yellow and thick, and dries into a scab. On the fifth day of the eruption they are almost all dried and covered with a slight crust. The inflammation of these pocks is very small, and the contents of them do not seem to be owing to suppuration, as in the smallpox, but rather to what is extravasated under the cuticle by the serous vessels of the skin, as in a common blister. It is not wonderful, therefore, that this liquor appears so soon as on the second day; and that, upon the cuticle being broken, it is presently succeeded by a slight scab: hence too, as the true skin is so little affected, no mark or scar is likely to be left, unless in one or two pocks, where, either by being accidentally much fretted or by some extraordinary sharpness of the contents a little ulcer is formed in the skin.

Varicella.

The patients scarce suffer any thing throughout the whole progress of this illness, except some languidness of strength, spirits, and appetite; all which is probably owing to the confining of themselves to their chamber.

Remedies are not likely to be much wanted in a disease attended with hardly any inconvenience, and which in so short a time is certainly cured of itself.

The principal marks by which the chickenpox may be distinguished from the smallpox are,

1. The appearance, on the second or third day from the eruption, of that vesicle full of serum upon the top of the pock.

2. The crust which covers the pocks on the fifth day; at which time those of the smallpox are not at the height of their suppuration.

Foreign medical writers hardly ever mention the name of this distemper: and the writers of our own country scarce mention any thing more of it than its name. Morton speaks of it as if he supposed it to be a very mild genuine smallpox. But these two distempers are certainly totally different from one another, not only on account of their different appearances above mentioned, but because those who have had the smallpox are capable of being infected with the chickenpox; but those who have once had the chickenpox are not capable of having it again, though to such as have never had this distemper, it seems as infectious as the smallpox. Dr Heberden wetted a thread in the most concocted pus-like liquor of the chickenpox which he could find; and after making a slight incision,

Exanthemata.

sion, it was confined upon the arm of one who had formerly had it; the little wound healed up immediately, and showed no signs of any infection.

From the great similitude between the two distempers, it is probable, that instead of the smallpox, some persons have been inoculated from the chickenpox; and that the distemper which has succeeded, has been mistaken for the smallpox by hasty or unexperienced observers.

There is sometimes seen an eruption, concerning which Dr Heberden is in doubt whether it be one of the many unnoticed cutaneous diseases, or only a more malignant sort of chickenpox.

This disorder is preceded for three or four days by all the symptoms which forerun the chickenpox; but in a much higher degree. On the fourth or fifth day the eruption appears, with a very little abatement of the fever: the pains likewise of the limbs and back still continue, to which are joined pains of the gums. The pox are redder than the chickenpox, and spread wider; and hardly rise so high, at least not in proportion to their size. Instead of one little head or vesicle of a serous matter, these have from four to ten or twelve. They go off just like the chickenpox, and are distinguishable from the smallpox by the same marks; besides which, the continuance of the pains and fever after the eruption, and the degree of both these, though there be not above 20 pocks, are circumstances never happening in the smallpox.

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Genus XXX. RUBEOLA.

Measles.

Rubeola, *Sauv.* gen. 94. *Lin.* 4. *Sag.* 293.
Febris morbillosa, *Vog.* 36. *Hoffm.* II. 62.
Morbilli, *Junck.* 76.

Sp. I. The *Regular Measles.*

Rubeola vulgaris, *Sauv.* sp. 1.
Morbilli regulares, *Sydenh.* sect. iv. cap. 5.

Var. 1. The *Anomalous Measles.*

Rubeola anomala, *Sauv.* sp. 2.
Morbilli anomali, *Sydenh.* sect. v. cap. 3.

Var. 2. The *Measles* attended with *Quinsy.*

Var. 3. The *Measles,* with *Putrid Diathesis* of the Blood.

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Sp. II. The *Variolodes.*

In Scotland commonly called the *Nirles.*

Rubeola variolodes, *Sauv.* sp. 3.

Description. This disease begins with a cold stage, which is soon followed by a hot, with the ordinary symptoms of thirst, anorexia, anxiety, sickness, and vomiting; and these are more or less considerable in different cases. Sometimes from the beginning the fever is sharp and violent; often, for the first two days, it is obscure and inconsiderable; but always becomes violent before the eruption, which commonly happens on the fourth day. This eruptive fever, from the beginning of it, is always attended with hoarseness, a frequent hoarse dry cough, and often with some difficulty of breathing. At the same time, the eyelids are somewhat swelled; the eyes are a little inflamed, and pour out tears; and with this there is a coryza, and frequent sneezing. For the most part, a constant drowsiness attends the beginning of this disease. The eruption, as we have said, commonly appears upon the fourth day, first on the face, and successively on the lower parts of the body. It appears first in small red points; but soon after, a number of these appear in clusters, which do not arise in visible pimples, but, by the touch, are found to be a little prominent. This is the case on the face; but, in other parts of the body, the prominency, or roughness, is hardly to be perceived. On the face, the eruption retains its redness, or has it increased, for two days; but on the third, the vivid redness is changed to a brownish red; and in a day or two more the eruption disappears, while a mealy desquamation takes place. During the whole time of the eruption, the face is somewhat turgid, but seldom considerably swelled. Sometimes, after the eruption has appeared, the fever ceases entirely: but this is seldom the case; and more commonly the fever continues or is increased after the eruption, and does not cease till after the desquamation. Even then the fever does not always cease, but continues with various duration and effect. Though the fever happen to cease upon the eruption's taking place, it is common for the cough to continue till after the desquamation. and sometimes much longer. In all cases, while the fever continues, the cough also continues, generally with an increase of the difficulty of breathing; and both of these symptoms sometimes arise to a degree which denotes a pneumonic affection. This may happen at any period of the disease; but very often it does not come on till after the desquamation of the eruption.

Rubeola.

After the same period, also, a diarrhœa frequently comes on, and continues for some time.

It is common for measles, even when they have not been of a violent kind, to be followed by inflammatory affections, particularly ophthalmia and phthisis. If blood be drawn from a vein in the measles, with circumstances necessary to favour the separation of the fibrine, this always appears separated, and lying on the surface of the crassamentum, as in inflammatory diseases. For the most part, the measles, even when violent, are without any putrid tendency; but in some cases, such a tendency appears both in the course of the disease, and especially after the ordinary course of it is finished.

Causes. The measles are occasioned by a peculiar kind of contagion, the nature of which is not understood; and which, like that of the smallpox, affects a person only once in his life.

Prognosis. From the description of this distemper already given, it appears that the measles are attended with a catarrhal affection, and with an inflammatory diathesis to a considerable degree; and therefore the danger of them is to be apprehended chiefly from the coming on of a pneumonic inflammation.

Cure. In measles, as well as in smallpox, the disease from its nature must necessarily run a determined course; and therefore the sole aim of a practitioner is to conduct this course in the easiest manner, by preventing and obviating urgent symptoms.

From the consideration mentioned in the prognosis, it

Exanthemata.

it will be obvious, that the remedies especially necessary are those which may obviate and diminish the inflammatory diathesis; and therefore, in a particular manner, blood-letting. This remedy may be employed at any time in the course of the disease, or after the ordinary course of it is finished. It is to be employed more or less according to the urgency of the symptoms of fever, cough, and dyspnœa; and generally may be employed very freely. But as the symptoms of pneumonic inflammation seldom come on during the eruptive fever, and as this is sometimes violent immediately before the eruption, though a sufficiently mild disease be to follow; bleeding is seldom very necessary during the eruptive fever, and may often be reserved for the times of greater danger which are perhaps to follow.

In all cases of measles, where there are marks of putrescency, and where there is no reason, from the known nature of the epidemic, to apprehend putrescency, bleeding is the remedy most to be depended upon: but assistance may also be drawn from cooling purgatives; and from blistering on the sides or between the shoulders. The dry cough may be alleviated by the large use of demulcent pectorals, mucilaginous, oily, or sweet. It may, however, be observed, with respect to these demulcents, that they are not so powerful in involving and correcting the acrimony of the mass of blood as has been imagined; and that their chief operation is by lubricating the fauces, and thereby defending them from the irritation of acrids, either arising from the lungs or distilling from the head. For moderating and quieting the cough in this disease, opiates certainly prove the most effectual means, whenever they can be safely employed. In the measles, in which an inflammatory state prevails in a considerable degree, opiates have indeed by some been supposed to be inadmissible: but experience abundantly demonstrates, that the objection made to their use is merely hypothetical: and even in cases where, from a high degree of pyrexia and of dyspnœa, there is reason to fear the presence, or at least the danger, of pneumonic inflammation, opiates are highly useful, after bleeding, to obviate or abate the inflammatory state, has been duly employed: in such cases, while the cough and watchfulness are the urgent symptoms, opiates may be safely exhibited, and with great advantage. In all the exanthemata, there is an acrimony diffused over the system, which gives a considerable irritation; and for obviating the effects of this, opiates are useful, and always proper, when no particular contraindication prevails.

When the desquamation of the measles is finished, though then there should be no disorder remaining, physicians have thought it necessary to purge the patient several times, with a view to draw off what have been called the *dregs of this disease;* that is, a portion of the morbific matter which is supposed to remain long in the body. Dr Cullen does not reject this supposition; but at the same time cannot believe that the remains of the morbific matter, diffused over the whole mass of blood, can be wholly drawn off by purging; and therefore thinks, that, to avoid the consequence of the measles, it is not the drawing off the morbific matter which we need to study, so much as to obviate and remove the inflammatory state of the system which had been induced by the disease. With this last view, indeed, purging may still be a proper remedy; but bleeding, in proportion to the symptoms of inflammatory disposition, is still more so.

Miliaria.

From our late experience of the use of cold air in the eruptive fever of the smallpox, some physicians have been of opinion that the practice may be transferred to the measles; but this point has not yet been determined by sufficiently extensive experience. We are certain, that external heat may be very hurtful in the measles, as in most other inflammatory diseases; and therefore, that the body ought to be kept in a moderate temperature during the whole course of the disease: but how far, at any period of the disease, cold air may be applied with safety, is still uncertain. Analogy, though so often the resource of physicians, is frequently fallacious; and further, though the analogy with the smallpox might lead to the application of cold air during the eruptive fever of the measles, the analogy with catarrh seems to be against the practice.

When the eruption is upon the skin, there are many instances of cold air making it disappear, and thereby producing much disorder in the system; and there are also frequent instances of these symptoms being removed by restoring the heat of the body, and thereby again bringing out the eruption.

Upwards of 20 years ago, inoculation for the measles was proposed, and practised in several instances with success, by Dr Home of Edinburgh. His method of communicating the infection was, by applying to an incision in each arm cotton moistened with the blood of a patient labouring under the measles; but with others who have made similar trials, the attempt has not yet succeeded. Attempts have been made to inoculate this disease by means of the fluid discharged under the form of tears, the squamæ falling from the surface and the like; but there is reason to believe, that where it was imagined the infection had thus been communicated, the contagion was only carried about the person inoculating and communicated in the ordinary way.

From inoculation of the measles, it is imagined that several advantages may be obtained; and among others, it is thought the soreness of the eyes may be mitigated, the cough abated, and the fever rendered less severe. But the practice was never much employed, and now is scarce ever heard of.

Genus XXXI. MILIARIA. 229

The *Miliary Fever.*

Miliaria, *Lin.* 7.
Miliaris, *Sauv.* gen. 95. *Sag.* gen. 295.
Febris miliaris, *Vog.* 37.
Febris purpurata rubra et alba miliaris, *Hoffm.* II. 68.
Febris purpurea seu miliaris, *Junck.* 75.
Germanis der Friesel. *God. Welsch.* Hist. Med de novo puerperarum morbo, qui der *Friesel* dicitur, Lips. 1655.
Hamilton, de febr. miliar. 1710. *Fontanus*, de febr. mil. 1747. *Allioni* de miliar. 1758. *Fordyce*, de febr. mil. 1748. *Fischer*, de febr. mil. 1767. De *Haen*, de divis. febr. 1760, et in Ration. med. passim. *Matt. Collin* ad *Baldinger* de miliar. 1764.

Exanthemata. Miliaria.

Miliaris benigna, *Sauv.* sp. 1.
Miliaris maligna, *Sauv.* sp. 2.
Miliaris recidivans, *Sauv.* sp. 3.
Miliaris Germanica, *Sauv.* sp. 5.
Miliaris Boia, *Sauv.* sp. *a.*
Miliaris Britannica, *Sauv.* sp. *i.*
Miliaris nova febris, *Sydenh.* Sched. monit. *Sauv.* sp. *d.*
Miliaris sudatoria, *Sauv.* sp. *e.*
Miliaris nautica, *Sauv.* sp. *g.*
Miliaris purpurata, *Sauv.* sp. *h.*
Miliaris lactea, *Sauv.* sp. *c.*
Miliaris puerperarum, *Sauv.* sp. *k.*
Miliaris scorbutica, *Sauv.* sp. *l.*
Miliaris critica, *Sauv.* sp. *b.*

History and Description. This disease is said to have been unknown to the ancients, and that it appeared for the first time in Saxony about the middle of the last century. It is said to have since spread from thence into all the other countries of Europe; and since the period mentioned, to have appeared in many countries in which it had never appeared before.

From the time of its having been first taken notice of, it has been described and treated of by many different writers; and by all of them, till very lately, has been considered as a peculiar idiopathic disease. It is said to have been constantly attended with peculiar symptoms. It comes on with a cold stage, which is often considerable. The hot stage, which follows, is attended with great anxiety, and frequent sighing. The heat of the body becomes great, and soon produces profuse sweating, preceded, however, with a sense of pricking, as of pin points in the skin; and the sweat is of a peculiar rank and disagreeable odour. The eruption appears sooner or later in different persons, but at no determined period of the disease. It seldom or never appears upon the face; but appears first upon the neck and breast, and from thence often spreads over the whole body.

The eruption named *miliary*, is said to be of two kinds; the one named the *red*, the other the *white miliary*. The former, which in English is strictly named a *rush*, is commonly allowed to be a symptomatic affection; and as the latter is the only one that has any pretensions to be considered as an idiopathic disease, it is this only that we shall more particularly describe and treat of under this genus.

What is then called the *white miliary eruption*, appears at first like the red, in very small red pimples, for the most part distinct, but sometimes clustered together. Their little prominence is better distinguished by the finger than by the eye. Soon after the appearance of this eruption, and, at least, on the second day, a small vesicle is visible upon the top of the pimples. At first the vesicle is whey-coloured: but soon becomes white, and stands out like a little globule. In two or three days, these globules break, or are rubbed off; and are succeeded by small crusts, which soon after fall off in small scales. While one set of pimples takes this course, another set arises to run the same; so that the disease often continues upon the skin for many days together. Sometimes when one crop of this eruption has disappeared, another, after some interval, is produced. And it has been further observed, that in some persons there is such a disposition to this disease, that they have been affected with it several times in the course of their lives.

This disease is said to affect both sexes, and persons of all ages and constitutions: but it has been observed at all times to affect especially, and most frequently, lying-in women.

It is often accompanied with violent symptoms, and has frequently proved fatal. The symptoms, however, attending it are very various; but no symptom, or concourse of symptoms, are steadily the same in different persons, so as to give any specific character to the disease. When the disease is violent, the most common symptoms are phrenetic, comatose, and convulsive affections, which are also symptoms of all fevers treated by a very warm regimen.

While there is such a variety of symptoms appearing in this disease, it is not to be expected that any one particular method of cure can be proposed; and, accordingly, we find in different writers different methods and remedies prescribed; frequent disputes about the most proper; and those received and recommended by some, opposed and deserted by others.

It appears, however, to Dr Cullen, very improbable, that this was really a new disease, when it was first considered as such. There are very clear traces of it in authors who wrote long before that period; and though there were not, we know that ancient descriptions were often inaccurate and imperfect, particularly with respect to cutaneous affections; and we know also that those affections which commonly appeared as symptomatic only, were often neglected, or confounded together under a general appellation.

The antecedent symptoms of anxiety, sighing, and pricking of the skin, which have been spoken of as peculiar to this disease, are, however, common to many others: and perhaps to all those in which sweatings are forced out by a warm regimen. Of the symptoms said to be concomitant of this eruption, there are none which can be affirmed to be constant and peculiar but that of sweating. This, indeed, always precedes and accompanies the eruption: and, while the miliary eruption attends many different diseases, it never, however, appears in any of these but after sweating; and in persons labouring under the same diseases it does not appear, if in such persons sweating be avoided. It is therefore probable, that the eruption is the effect of sweating: and that it is the effect of a matter not before prevailing in the mass of blood, but generated under particular circumstances in the skin itself. That it depends upon particular circumstances of the skin, is also probable from its being observed that the eruption seldom or never appears upon the face, although it affects the whole of the body besides; and that it comes upon those places especially which are more closely covered; and that it can be brought out upon particular places by external applications.

It is to be observed, that this eruptive disease differs from the other exanthemata in many circumstances, especially the following; that it is not contagious, and therefore never epidemic; that the eruption appears at no determined period of the disease; that the eruption has no determined duration; that successive eruptions frequently appear in the course of the same fever,

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fever, and that such eruptions frequently recur in the course of the same person's life. All this renders it very probable, that, in the miliary fever, the morbific matter is not a subsisting contagion communicated to the blood, and thence, in consequence of fever and assimilation, thrown out upon the surface of the body, but a matter occasionally produced in the skin itself by sweating.

This conclusion is further rendered probable from hence, that, while the miliary eruption has no symptoms or concourse of symptoms peculiar to itself, it, upon occasions, accompanies almost every febrile disease, whether inflammatory or putrid, if these happen to be attended with sweating; and from thence it may be presumed, that the miliary eruption is a symptomatic affection only, produced in the manner we have said.

But as this symptomatic affection does not always accompany every instance of sweating, it may be proper to inquire, what are the circumstances which especially determine this eruption to appear? And to this Dr Cullen gives no full and proper answer. He cannot say that there is any one circumstance which in all cases gives occasion to this eruption; nor can he say what different causes, in different cases, may give occasion to it. There is only one observation that can be made to the purpose; and it is, that these persons, sweating under febrile diseases, are especially liable to the miliary eruption, who have been previously weakened by large evacuations, particularly of blood. This will explain why it happens to lying-in women more frequently than to any other persons; and to confirm this explanation, he has observed, that the eruption has happened to other women, though not in childbed, but who had been much subjected to a frequent and copious menstruation, and to an almost constant *fluor albus*. He has also observed it to have happened to men in fevers, after wounds from which they had suffered a great loss of blood.

Further, That this eruption is produced by a certain state of debility, is, he thinks, probable, from its so often attending fevers of the putrid kind, which are always accompanied with great debility. It is true, that it also sometimes attends inflammatory diseases, when it cannot be accounted for in the same manner; but he believes it may be observed, that it especially attends those inflammatory diseases in which the sweats have been long protracted, or frequently repeated, and which have thereby produced a debility, and perhaps a debilitating putrid diathesis.

That, however, the miliary eruption is not necessarily or even generally connected with a certain state of debility, is abundantly evident from its being entirely wanting in by much the greater number of instances of typhoid fever, and in a variety of other diseases where every possible degree of debility occurs: And that it is not connected with any certain state of debility, still farther appears, both from the condition of those affected with it in different instances, which in point of strength is very various; and likewise from the continuance of fresh eruptions with the same individual, although during that time in very different states with respect to debility. It appears, therefore, much more probable, that it depends on some peculiar state of the surface, induced by the concurring influence of certain predisposing and occasional causes.

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It appears so clearly that this eruption is always a symptomatic and factitious affection, that Dr Cullen is persuaded it may be, in most cases, prevented merely by avoiding sweats. Spontaneous sweatings, in the beginning of diseases, are very rarely critical; and all sweatings not evidently critical should be prevented, or at least moderated; and the promoting them, by increasing external heat, is commonly very pernicious. Even critical sweats should hardly be encouraged by such means. If, therefore, spontaneous sweats arise, they are to be checked by the coolness of the chamber; by the lightness and looseness of the bedclothes; by the persons laying out their arms and hands; and by their taking cold drink: and in this way Dr Cullen thinks he has frequently prevented miliary eruptions, which were otherwise likely to have appeared, particularly in puerperal women.

But it may happen, when these precautions have been neglected, or from other circumstances, that a miliary eruption does actually appear; and the question will then be put, how the case is to be treated? This is a question of consequence; as there is reason to believe that the matter here generated is often of a virulent kind; it is often the offspring of putrescency; and, when treated by increasing the external heat of the body, it seems to acquire a virulence which produces those symptoms mentioned above, and proves certainly fatal.

It has been an unhappy opinion with most physicians, that eruptive diseases were ready to be hurt by cold; and that it was therefore necessary to cover up the body very closely, and thereby increase the external heat. We now know that this is a mistaken opinion; that increasing the external heat of the body is very generally mischievous; and that several eruptions not only admit, but require the application of cold air. Dr Cullen is persuaded, therefore, that the practice which formerly prevailed in the case of miliary eruptions, of covering up the body closely, and both by external means and internal remedies encouraging the sweatings which accompany this eruption, was highly pernicious, and commonly fatal. He is therefore of opinion, that even when a miliary eruption has appeared, in all cases in which the sweating is not manifestly critical, we should employ all the means of stopping the sweating that are mentioned above; and he has sometimes had occasion to observe, that even the admission of cool air was safe and useful.

This is, in general, the treatment of miliary eruptions: but at the same time, the remedies suited to the primary disease are to be employed; and therefore when the eruption happens to accompany inflammatory affections, and the fulness and hardness of the pulse or other symptoms show an inflammatory state present, the case is to be treated by blood-letting, purging, and other antiphlogistic remedies.

On the other hand, when the miliary eruption attends diseases in which debility and putrescency prevail, it will be proper to avoid all evacuations, and to employ tonic and antiseptic remedies, particularly the cinchona, cold drink, and cold air.

The most distressing circumstance attending this affection, is the almost unsupportable sickness at stomach which frequently occurs, and which is often observed to precede fresh eruptions taking place during the

the course of the disease. With the view of counteracting and alleviating this symptom, recourse is had to wine and other cordial medicines. But with many patients nothing is found to have so much influence as the use of camphor, particularly when introduced gradually in small doses, under the form of the *mistura camphorata* of the London Pharmacopœia, or of the *emulsio camphorata* of that of Edinburgh.

Genus XXXII. SCARLATINA.

Scarlet Fever.

Scarlatina, *Sauv.* gen. 98. *Vog.* 39. *Sag.* 294. *Junck.* 75.

Sp. I. The Mild *Scarlet Fever.*

Scarlatina febris, *Sauv.* sp. 1. *Sydenham*, sect. vi. cap. 2,

Sp. II. The *Scarlet Fever* with *Ulcerated Sore Throat.*

Scarlatina anginosa. *Withering* on the Scarlet Fever.

The mild scarlet fever is described by Sydenham, who tells us that he can scarce account it a disease; and indeed nothing more seems to be necessary in the treatment of it than an antiphlogistic regimen, avoiding the application of cold air and cold drink. The disease, however, often rages epidemically, and is attended with very alarming symptoms, in which case it is called *scarlatina anginosa*.—The best description of this distemper has been published by Dr Withering in the year 1778. This disease made its appearance, we are told, at Birmingham and the neighbouring villages, about the middle of May 1778. It continued in all its force and frequency to the end of October; varying, however, in some of its symptoms, as the air grew colder. In the beginning of November it was rarely met with; but towards the middle of that month, when the air became warmer, it increased again, and in some measure resumed those appearances it possessed in the summer months, but which it had lost during the cold winds in October.

It affected children more than adults; but seldom occurred in the former under two years of age, or in the latter if they had passed their fiftieth year.

Description. With various general symptoms of fever, the patient at first complains of a dejection of spirits, a slight soreness or rather stiffness in the neck, with a sense of straitness in the muscles of the neck and shoulders, as if they were bound with cords. The second day of the fever this soreness in the throat increases, and the patients find a difficulty in swallowing: but the difficulty seems less occasioned by the pain excited in the attempt, or by the straitness of the passage, than by an inability to throw the necessary muscles into action. The skin feels hot and dry, but not hard; and the patients experience frequent, small pungent pains, as if touched with the point of a needle. The breath is hot and burning to the lips, and thirst makes them wish to drink; but the tendency to sickness, and the exertions necessary in deglutition, are so unpleasant, that they seldom care to drink much at a time. They have much uneasiness also from want of rest during the night. In the morning of the third day, the face, neck, and breast, appear redder than usual: in a few hours this redness becomes universal; and increases to such a degree of intensity, that the face, body, and limbs, resemble a boiled lobster in colour, and are evidently swollen. Upon pressure the redness vanishes, but soon returns again. The skin is smooth to the touch, nor is there the least appearance of pimples or pustules. The eyes and nostrils partake more or less of the general redness; and in proportion to the intensity of this colour in the eyes, the tendency to delirium prevails.

Things continue in nearly this state for two or three days longer, when the intense scarlet gradually abates, a brown colour succeeds, and the skin becoming rough, peels off in small scales. The tumefaction subsides at the same time, and the patients gradually recover their strength and appetite.

During the whole course of the disease, the pulse is quick, small, and uncommonly feeble, the urine small in quantity; the sub-maxillary glands somewhat enlarged and painful to the touch. The velum pendulum palati, the uvula, the tonsils, and gullet, as far as the eye can reach, partake of the general redness and tumefaction; but although collections of thick mucus, greatly resembling the specks or sloughs in the putrid sore throat, sometimes occur, yet those are easily washed off; and real ulcerations of those parts were never observed.

These are the most usual appearances of this disorder; but it too frequently assumes a much more fatal form. In some children the delirium commences in a few hours after the first attack; the skin is intensely hot; the scarlet colour appears on the first or second day, and they die very early on the third. Others again, who survive this rapid termination, instead of recovering, as is usual about the time the skin begins to get its natural colour, fall into a kind of lingering, and die at last in the course of six or eight weeks.

In adults, circular livid spots were frequently observed about the breast, knees, and elbows; also large blotches of red, and others of white intermixed, and often changing places.

In the month of October, when the air became colder, the scarlet colour of the skin was both less frequent and less permanent. Many patients had no appearance of it at all; while others, especially adults, had a few minute red pimples, crowned with white pellucid heads. The inside of the throat was considerably tumefied, its colour a dull red, sometimes tending to a livid. The pulse beat in general 130 or 140 strokes in a minute; was small, but hard, and sometimes sufficiently so to justify the opening of a vein; and the blood thus taken away, in every instance, when cool, appeared sizy, and the whole crassamentum firm.

Happy would it be, Dr Withering observes, if the baneful influence of this disorder terminated with the febrile symptoms. But in ten or fifteen days from the cessation of the fever, and when a complete recovery might be expected, another train of symptoms occurs, which at last frequently terminate fatally. The patients, after a few days amendment, feel a something that prevents their farther approach to health;

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health; an unaccountable languor and debility prevail, a stiffness in the limbs, an accelerated pulse, disturbed sleep, disrelish to food, and a scarcity of urine. These symptoms, we are told, are soon succeeded by swellings of a real dropsical nature, forming sometimes an anasarca, and on other occasions an ascites; and not unfrequently scarlatina has proved fatal, from supervening hydrothorax in consequence of the effusion of water into the chest. It is unnecessary to remark, that when this happens, a fatal termination is more sudden than from any other modification of dropsy.

Dr Withering, after examining the accounts given of this disease by different authors, proceeds to the diagnosis. It may be distinguished, he observes, from the petechial fever, by the eruption in the latter appearing seldom before the fourth day, by the regularity and distinctness of the spots, and by its principally occupying the neck, the back, and the loins. On the other hand, in the scarlet fever, the eruption generally appears about the third day; and consists either of broad blotches, or else one continued redness, which spreads over the face and the whole body.

In the fever called *purpura*, the pustules are prominent, keep their colour under pressure, and never appear early in the disease; whereas in the scarlet fever, the eruption appears more early, is not prominent, but perfectly smooth to the touch, and becomes quite white under pressure.

Although the *purple fever* and *scarlatina* may be connected by some general cause, yet our author takes occasion to observe, that they cannot be mere modifications of the same eruption: for examples occur, he says, of the same person being first seized with one of these disorders, and afterwards with the other; but he never met with an instance of the same person having the scarlet fever twice; and he believes it to be as great an improbability as a repetition of the smallpox.

This disorder is particularly distinguished from the *measles*, we are told, by the want of that cough, watery eye, and running at the nose, which are known to be the predominant symptoms in the early state of the measles, but are never known to exist in the scarlatina.

From the *erysipelas* this disease is distinguishable, by the limited seat of the former, together with its not being contagious.

The *cynanche maligna*, however, is, according to Dr Withering, more difficult to distinguish from this disease than any other; and yet the distinction is, he thinks, a matter of the greatest importance, as the method of treatment, according to him, ought to be extremely different.—Although, in a number of circumstances, these two diseases bear a very great resemblance, yet, with a little attention, the one may in general, he thinks, be distinguished from the other. From Dr Fothergill's account of the sore throat attended with ulcers, our author has made out the following characteristical circumstances of the two diseases, contrasted to one another.

Scarlatina Anginosa.	Angina Gangrenosa.
Season. . Summer . . Autumn.	*Season.* . Spring . . Winter.
Air . . Hot . . . Dry.	*Air.* . Warm . . Moist.
Places. High . . Dry . . . Gravelly.	*Places.* Close . . Low . . Damp . . Marshy.
Subjects. Vigorous. Both sexes alike. . Robust in most danger. . . .	*Subjects.* Delicate . . Women and female children. Robust adults not in danger.
Skin. Full scarlet . . . . smooth . . If pimply, the pimples white at the top . . Always dry and hot.	*Skin.* Red tinct . . pimply. . The pimples redder than the interstices . . bedewed with sweat towards morning.
Eyes. Shining, equable, intense redness, rarely watery.	*Eyes.* Inflamed and watery, or sunk and dead.
Throat. In summer, tonsils, &c. little tumefied; no slough . . In autumn, more swelled. Integuments separating . . Sloughs white.	*Throat.* Tonsils, &c. considerably swelled and ulcerated . . . Sloughs dark brown.
Breath. Very hot, but not fetid.	*Breath.* Offensive to the patients and assistants.
Voice. In summer, natural.	*Voice.* Flat and rattling.
Bowels. Regular at the accession.	*Bowels* . . Purging at the accession.
Blood. Buffy. . Firm.	*Blood.* . Florid . . *Tender.*
Termination. The 3d, 5th, 8th, or 11th day.	*Termination.* No stated period.
Nature. Inflammatory.	*Nature.* Putrid.

It is not pretended, Dr Withering remarks, that all the above contrasted symptoms will be met with in every case. It is enough, he observes, that some of them appear; and that if, conjoined with the consideration of the prevailing constitution, they enable us to direct that mode of treatment which will most contribute to the relief of the sick.

But notwithstanding the attention which Dr Withering has bestowed upon this subject, we are still decidedly of opinion, that the disease which he has so accurately described under the title of *scarlatina anginosa*, is in reality the same affection with the malignant ulcerous sore throat of Huxham and Fothergill. During different epidemics, this disease, like smallpox and measles, in different seasons, is considerably varied in its appearance. But still there occurs such a similarity as clearly marks the sameness of the affection. And indeed this, as in the case of the smallpox, is abundantly demonstrated by infection from one contagion giving protection against succeeding ones, although the appearances be much varied. This has particularly appeared at Edinburgh, where the disease has of late prevailed as an epidemic on five different years, viz. 1774-75, 1782-83, 1789-90, 1797-98, and 1804-5. During the first of these occasions, in the greater part of patients, the sore throats were of a very gangrenous and malignant nature: during the second, the disease more commonly appeared under the form of what might be called *simple scarlatina:* and during the other epidemics, the contagion was, if we may be allowed the expression, of an intermediate nature. But it is farther to be remarked, that during every one of those epidemics, when several children of a family were at the same time subjected

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subjected to the infection, in one the disease would have been attended with almost all the symptoms mentioned in the column of *scarlatina anginosa*, with respect to skin, eyes, throat, breath, bowels, termination of the affections, &c. In another, would have occurred all the symptoms with respect to those particulars which he has mentioned under the column of *angina gangrenosa*. While at the same time, in numberless instances, even in the same patient, the disease at its commencement has shown evident marks of an inflammatory, and at its termination of a putrid tendency. And there cannot be a doubt, that both the scarlatina anginosa of Withering, and the cynanche maligna, as described by Fothergill and Huxham, have occurred in every season and situation, and have affected persons of every age and constitution not before subject to either disease.

Causes. 1. Dr Withering affirms, that the immediate cause of this disease is a poison of a peculiar kind communicable by contagion.

2. That this poison first takes possession of the mucous membrane lining the fauces and the nose; and either by its action upon the secretory glands, or upon the mucus itself, assimilates that mucus to its own nature.

3. That it is from this beginning, and from this only, that it spreads to the stomach, &c. and at length acts upon the system at large.

4. That its first action upon the nerves is of a sedative or debilitating nature.

5. That in consequence of certain laws of the nervous system, when the debilitating effects operate upon the sensorium commune, a reaction takes place; and that this reaction is, *cæteris paribus*, proportioned to the debilitating power.

6. That, in consequence of this reaction of the nervous system, the vibratory motion of the capillary blood-vessels dependant thereon is greatly increased; an unusually large quantity of blood is accumulated in those vessels; the heart and large blood-vessels are deprived of their customary proportion; and hence, though stimulated to more frequent contraction, the pulse must necessarily be feeble.

7. That as violent exertions are followed by debility, upon the cessation of the fever, the capillary vessels, which had acted with such unusual violence, are left in a state of extreme debility, and are long in recovering their tone; hence it is that so many patients afterwards become dropsical.

Dr Withering next proceeds to the consideration of the different remedies which either are at present in common use, or have been recommended as proper in this disease.

Cure. Blood-letting has been recommended by authors; but such was the state of the pulse in this disorder, at least during the summer months, that it was not in any instance thought advisable to take away blood. In some cases, indeed, where the fiery redness of the eyes seemed to demand the use of leeches, they were had recourse to, but never with any advantage. In the harvest months, when the pulse was more firm, and when suffocation seemed to be threatened from the swelling in the fauces, blood-letting was sometimes advised; but still with less advantage than one would have expected in almost any other situation.

Vomiting.] This, Dr Withering observes, seems to be the remedy of nature; and he is surprised how it should have been omitted by several authors who have gone before him. Vomiting, he says, most amply fulfils the indications arising both from a consideration of the cause and of the effects; and a liberal use of the remedy he holds forth as the true foundation for successful practice in scarlet fever and sore throat. His common form of emetic is a combination of tartar emetic and ipecacuanha, given in pretty smart doses; and these are to be repeated at least once in 48 hours, and in the worst cases so often as twice in 24 hours.

Purging.] The action of purgatives is considered by Dr Withering as altogether repugnant to the curative indications in this disease: for the poisons, as formerly remarked, being received into the system by the fauces, the operation of a purge, instead of discharging it, can only promote its diffusion along the alimentary canal; and, in fact, we are told, that when even a spontaneous purging supervenes in this disease, the patients sink so amazingly fast, that it is not within the reach of art to support them. When, however, a considerable quantity of acrid matter passing from the fauces into the stomach, makes its way to the rectum, a considerable degree of looseness often takes place. And although evacuations from the system in general by means of cathartics may be hurtful, yet patients often obtain great relief from a free discharge of this matter; and by discharging it, purgatives have the effect even of preventing an evacuation from the system, which would otherwise take place.

Sudorifics. Cordials. Alexipharmics.] None of these remedies were found beneficial. With respect to cordials, Dr Withering observes, that although they seem to be indicated by the great loss of strength and feeble pulse, yet the certain consequence of their use always was, an increase of restlessness, of the delirium, and of the heat.

Diuretics.] These were found very beneficial. The vegetable fixed alkali is recommended as the most proper article of this kind: a dram or two may be easily swallowed every 24 hours, by giving a small quantity in every thing the patient drinks. Diuretics, however, have been found principally serviceable, by practitioners in general, in those cases where the urine is observed to be scanty, and where dropsical symptoms have taken place.

Cinchona.] No medicine, we are told, ever had a fairer trial in any disease than the Peruvian bark had in this epidemic; for the feeble pulse, great prostration of strength, with here and there a livid spot, were thought to be such undeniable evidences of a putrid tendency, that cinchona was poured down not with a sparing hand. But this was only at first; for these livid spots and the sloughs in the throat being found to be the effects of inflammation instead of putrefaction, and the bark instead of diminishing, rather increasing these symptoms, it was at last entirely laid aside by Dr Withering in his practice. But although cinchona may not have been successful with a particular epidemic at a particular place; yet from the concurring testimony of many practitioners, it is very commonly

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monly found to be productive of good effects: And there is perhaps no remedy on which greater dependance is in general put, particularly in the advanced periods of the disease, where the fœtor is considerable.

Upon the same principles that cinchona was prescribed, fixable air was at first likewise advised, but with no evident effects either one way or another. Dulcified acids were also had recourse to, but with no advantage.

Opiates.] These, although recommended by some authors for the removal of inquietude and watchfulness, yet in this epidemic, instead of effecting these purposes, always increased the distress of the patient.

Blisters.] In the summer appearance of the disease, blisters were universally detrimental; they never failed to hasten the delirium; and if the case was of the worst kind, they too often confirmed its fatal tendency. But although this may have been the case during the epidemic which Dr Withering describes, it has by no means been generally observed. On the contrary, by the early application of blisters to the external fauces, both the glandular swellings and likewise the discharge from the mouth and fauces have been much diminished; and practitioners have believed, not without probable reason, that the after-affections of the throat were less considerable than would otherwise have been the case.

Injected gargles of contrayerva decoction, sweetened with oxymel of squills, &c. were found very beneficial in bringing always large quantities of viscid ropy stuff from the fauces.

The immersion of the feet and legs in warm water, although it did no harm, yet did not either procure sleep or abate the delirium, as it frequently does in other kinds of fever.

As in summer it was found difficult to keep the patients sufficiently cool, they were ordered to lie upon a mattress instead of a feather-bed; a free circulation of air was kept up; and where the patients strength would admit of it, they were ordered frequently out of doors. Animal food and fermented liquors were denied them, and nothing allowed but tea, coffee, chocolate, milk and water, gruel, barley-water, and such articles.

With respect to the dropsical disorder which so frequently succeeds to this complaint, it was never observed, Dr Withering remarks, when the preceding symptoms had been properly treated.

When called upon to patients in the dropsical state, he began his practice by a dose of calomel at night, and a purgative in the morning. When a febrile pulse attended the other symptoms, emetics were useful, as well as the saline draughts and other neutral salts. When great debility, comatose or peripneumonic symptoms occurred, blisters were found very serviceable: but when dropsical symptoms were the principal cause of complaint, small doses of rhubarb and calomel were advised; recourse was also had to diluted solutions of fixed alkalies, squills, Seltzer waters, and other diuretics.

When the urine flows freely, steel and other tonics are recommended; together with gentle exercise, high-seasoned food, wine, and the wearing of flannel in contact with the skin.

Dr Withering concludes his essay with an enumeration of several cases, treated according to the principles above laid down. The successful termination of these cases demonstrates the propriety of the practice which he has recommended; at least for the epidemic under the form in which it then appeared.

Urticar.

Since Dr Withering's publication, two other practices have obtained considerable celebrity in this disease. The one is dashing cold water on the surface of the body in the manner recommended by Dr Currie in proper fevers. It is, however, very certain that although this may obviate symptoms, and particularly diminish the heat when very urgent, yet it never produces an artificial termination of the disease as some have alleged. When the contagion of scarlatina is introduced into a human body, never before subjected to the disease, it must, like smallpox and measles, run a certain course, and the attention of the practitioner must merely be employed in endeavouring to render that course as mild as he can, principally by obviating urgent symptoms.

The other remedy lately introduced, and highly commended in scarlatina anginosa, is the oxygenated muriatic acid. This has been particularly extolled by Mr John Ayrey Braithwaite, surgeon at Lancaster. One dram of the oxygenated muriatic acid is mixed with eight ounces of distilled water. This quantity he directs to be taken by a patient at the age of puberty every day. But the quantity must be regulated by the age and situation of the patient. This remedy also is very useful as obviating symptoms, particularly the affection of the throat. But with this intention we have often employed it with great advantage.

Genus XXXIII. URTICARIA.

Nettle-rash.

Febris urticata, *Vog.* 40.
Uredo, *Lin.* 8.
Purpura urticata, *Junck.* 75.
Scarlatina urticata, *Sauv.* sp. 2.
Erysipelatis species altera, *Sydenham*, sect. vi. cap. 6.
Febris scarlatina, et febris urticata, *Meyserey*, Mal. des armées, 291 et seq.

Description. This disease has its English name of nettle-rash from the resemblance of its eruption to that made by the stinging of nettles. These little elevations upon the skin in the nettle-rash often appear instantaneously, especially if the skin be rubbed or scratched, and seldom stay many hours in the same place, and sometimes not many minutes. No part of the body is exempt from them; and where many of them rise together, and continue an hour or two, the parts are often considerably swelled; which particularly happens in the face, arms, and hands. These eruptions will continue to infest the skin, sometimes in one place and sometimes in another, for one or two hours at a time, two or three times every day, or perhaps for the greatest part of the 24 hours.—In some persons they last only a few days, in others many months; nay, sometimes the disease has lasted for years with very short intervals.

But though the eruption of the urticaria resembles, as already observed, that produced by the stinging of nettles,

nettles, it is sometimes accompanied with long weals, as if the part had been struck with a whip. Whatever be the shape of these eminences, they always appear solid, without having any cavity or head containing either water or any other liquor: and this affords an easy mark whereby this disease may be distinguished from the itch. For it often happens, that the insufferable itching with which this eruption is attended, provokes the patient to scratch the parts so violently, that a small part of the cuticle on the top of these little tumours is rubbed off; a little scab succeeds; and, when the swelling is gone down, there is left an appearance hardly to be distinguished from the itch, but by the circumstance just now mentioned. The nettle-rash also further differs from the itch, in not being infectious.

Causes, &c. Dr Heberden is inclined to ascribe this distemper to some mechanical cause outwardly applied to the skin. He observes, that most people suffer in a similar manner from the real stinging of nettles. Cowhage, or, as it is corruptly called, *cow-itch*, a sort of phaseolus, or French bean, the pod of which is covered over with a kind of down or hair, and the effect of which upon the skin is much the same as that of nettles; and almost any hairs cut equally short, and sprinkled upon the skin, whenever they happen to stick in it, will make the part itch or smart in such a manner as to give great uneasiness; it is also a considerable time before the skin can be cleared of the finer ones, when once they are strewed upon it.

Reaumur, in the fourth memoir of his History of Insects, describes a species of caterpillars to which belong a sort of hairs almost invisible to the naked eye, which are easily detached, and frequently float in the air round their nest, though it have not been at all disturbed. The touch of these hairs has a similar effect with the cow-itch; that is, they occasion intolerable itchings with little bumps and redness, arising sometimes to a slight inflammation. These he found would continue four or five days, if the animal or the nest had been much handled; and though they had not been touched at all, yet by only walking near their nests, the same effects would be brought on, but for a shorter time. These hairs affect the skin in this manner by sticking in it, as he could perceive with a glass of a great magnifying power; for with one of a small power they were not visible. The uneasy sensations caused by these small wounds, not only, as he says, last several days, but move from one part of the body to another; so that they will cease upon one wrist, and immediately begin on the other; from the wrist they will go to the fingers or the face, or even to the parts of the body which are covered. He supposes, that the motions of the body, when much of this fine down lies near or upon the skin, may drive it from one part to another, or change what was lying there inoffensively to a situation fit to make it penetrate into the skin. Neither cold water, nor oil, nor spirit of wine, with which the parts affected were bathed, had any effect in removing the itching. He thinks the most efficacious remedy which he tried for this complaint was, to rub the parts strongly with parsley, which instantly lessened the sensations, and after two or three hours, entirely freed the patient from them. It is also well known that many species of caterpillars by only walking over the hands, will produce something like this effect on the parts which they touch, and undoubtedly from the same cause.

Dr Heberden asks, Is it impossible that the nettle-rash should arise from the same causes, or from others similar, which we miss by looking too deeply for them in the blood and humours? Such, says, he, may have been its origin in some instances, where it has lasted only a few days; but where this affection has continued for some years, in persons who change their linen every day, and who bathe frequently all the time, it can hardly be ascribed to such an external cause. He has observed it frequently to arise from cantharides: but though it has continued many weeks after the removal of the blister, yet it might be suspected that this arose from the fine spiculæ of the cantharides sticking all this time about the skin; it being customary to strew much of the dry powder of the cantharides over the blister-plaster, whence it may readily be carried to other parts of the body. But it is certain that similar effects will sometimes follow the internal use of wild valerian root, or the eating of fish not sufficiently dressed; muscles, shrimps, and even honey, and the kernels of fruits, will also sometimes produce symptoms of a similar kind. But whatever be its cause, Dr Heberden never saw any reason to suppose that the nettle-rash had in any way vitiated the humours to such a degree as to require the use of internal remedies; and if the itching could be certainly and expeditiously allayed, there would be no occasion for any farther cure. He concludes this history of the disorder with a case communicated to him by Dr Monsey, physician of Chelsea College, and in which the disease appeared with uncommon violence.

W. A. aged near 30, of a thin spare habit, was seized with a disorder attended with symptoms of a very uncommon kind. Whenever he went into the air, if the sun shined bright, he was seized with a tickling of his flesh on those parts exposed to the sun: this tickling, by his continuing in the air, increased to a violent itching, attended with great heat and pain: the skin would then be almost as red as vermilion, and thicken like leather; and this remained till he went out of the open air, and then abated in about 15 or 20 minutes. This happened only when the sun was above the horizon; at other times he was what he called *quite well*.—But it was not owing to the heat of the sun; for the sun in winter affected him full as much, if not more, and the heat of the fire had no such effect. Thus he was confined to the house for 10 years. He tried several hospitals, and had advices from many physicians, without the least abatement of his complaints. At last it was agreed by a consultation of physicians, that he should try dipping in salt water; which he did at Yarmouth for 13 weeks, without any visible amendment. One hot day, having pulled off his clothes and gone into the sea in the middle of the day, the heat diffused itself so violently all over his body, that, by the time he had put on his clothes, his eyesight began to fail, and he was compelled to lie down upon the ground to save himself from falling. The moment he lay down, the faintness went off: upon this he got up again; but had no sooner arisen, than he found himself in the former condition; he therefore lay down

Exanthemata. down again, and immediately recovered. He continued alternately getting up and lying down, till the disorder began to be exhausted, which was in about half an hour; and he was frequently obliged to have recourse to the same expedient.

Having at last accidentally met with Dr Monsey, this physician questioned him concerning the cause of the disorder; but nothing could be guessed at, excepting that the patient had owned he had one winter lived entirely upon bullock's liver and porter, from inability to purchase better victuals. A comrade lived with him at that time, on the same provisions; and he also was affected in a similar manner, though in a less degree, and had recovered. The patient was then first put upon a course of Dover's sweating powder without any effect, and afterwards tried a course of nitrous ones with the same bad success. At last Dr Monsey determined to try the effect of mercury, which happily proved effectual in removing this obstinate and uncommon distemper. The patient began with taking five grains of calomel for three nights running, and a cathartic next morning. In this course he went on for near a fortnight, at the end of which he found himself very sensibly relieved. This encouraged him to go on rather too boldly, by which means a slight salivation ensued; however, that went off soon, and in about six weeks he was quite well.—Some time after, he was threatened with a return of his disorder; but this was effectually relieved by a dose of calomel, which he had afterwards occasion to repeat for the same reason, and with the same success; but at last the disorder seemed to be radically cured, by his having no further symptoms of a relapse.

232 GENUS XXXIV. PEMPHIGUS.

Pemphigus, *Sauv.* gen. 93. *Sag.* 291.
Morta, *Lin.* 1.
Febris bullosa, *Vog.* 41.
Pemphigus major, *Sauv.* sp. 1.
Exanthemata serosa, *C. Pison.* Obs. 150.
Febris pemphygodes, *Ephem. Germ.* D. I. A. viii. Obs. 56.
Pemphigus castrensis, *Sauv.* sp. 2.
Febres synceches, cum vesiculis per pectus et collum sparsis, *Morton.* App. ad Excrc. II.
Pemphigus Helveticus, *Sauv.* sp. 3. *Langhans* in Act. Helvet. vol. ii. p. 260. et in *Beschreibung* des Siementhals, Zurich 1753.

This is a very rare disease, insomuch that Dr Cullen declares he never saw it. He declines taking the descriptions of foreign physicians: we shall therefore content ourselves with giving an instance of this very uncommon distemper, as it was observed in the Infirmary at Aberdeen, and was treated by the late Dr David Stuart, then physician to that hospital, who soon after published an account of it in the Edinburgh Medical Commentaries. A private soldier of the 73d regiment, aged eighteen years, formerly a pedlar, and naturally of a healthy constitution, was received into the hospital at Aberdeen on the 25th of April. About twenty days before that, he had been seized with the measles when in the country; and, in marching to town, on the second day of their eruption, he was exposed to cold; upon which they suddenly disappeared.

Pemphigus. Having arrived at Aberdeen, he was quartered in a damp, ill-aired, under-ground apartment. He then complained of sickness at stomach, great oppression about the præcordia, headach, lassitude, and weariness, on the least exertion; with stiffness and rigidity of his knees and other joints. The surgeon of the regiment visited him: he was purged, but with little benefit. About ten days before, he observed on the inside of his thighs a number of very small, distinct, red spots, a little elevated above the surface of the skin, and much resembling the first appearance of small-pox. This eruption gradually spread itself over his whole body, and the pustules continued every day to increase in size.

Upon being received into the hospital, he complained of headach, sickness at stomach, oppression about the præcordia, thirst, sore throat, with difficulty of swallowing; his tongue was foul, his skin felt hot and feverish; pulse from 110 to 120, rather depressed; belly costive; eyes dull and languid, but without delirium. The whole surface of his skin was interspersed with vesicles, or phlyctænæ, of the size of an ordinary walnut; many of them were larger, especially on the arms and breast. In the interstices, between the vesicles, the appearance of the skin was natural, nor was there any redness round their base; the distance from one to another was from half an inch to a handbreadth or more. In some places two or three were joined together, like the pustules in the confluent small-pox. A few vesicles had burst of themselves, and formed a whitish scab or crust. These were chiefly on the neck and face; others showed a tolerably laudable pus. However, by far the greatest number were perfectly entire, turgid, and of a bluish colour. Upon opening them, it was evident that the cuticle elevated above the cutis, and distended with a thin, yellowish, semi-pellucid serum, formed this appearance. Nor was the surface of the cutis ulcerated or livid; but of a red florid colour, as when the cuticle is separated by a blister, or superficial burning. No other person laboured under a similar disease, either in the part of the country from which he came, or when he resided in Aberdeen.

This case was treated in the following manner. The largest of the vesicles were snipped, and dressed with *unguent. è lap. calaminari.* In the evening he was vomited with a solution of tartar emetic, given in small quantities and at intervals. This also procured two loose stools. And he was ordered for drink, water-gruel acidulated with lemon juice.

"April 16. He still complained of sickness, some oppression about his breast, and sore throat; he had slept little during the night; his tongue was foul and blackish; his skin, however, was not so hot as the preceding day; his urine was high-coloured, but had the appearance of separation; his pulse 90, and soft; most of the sores on the trunk of the body looked clean. Others, particularly where the vesicles were confluent, seemed beginning to ulcerate, and to have a bluish sub-livid appearance. They were dressed afresh with cerate, and he was ordered the following medicines:

℞ Decoct. Cort. Peruvian, ℥vj. Vini rubr. Lusitan. ℥iij. M. Hujus mixturæ capiat ℥ß. tertia quaque hora.

"His

Pemphigus. Aphtha.

"His acidulated drink was continued; and on account of the very offensive smell on approaching near him, some vinegar was placed in a bason before the bed, and sprinkled on the floor; and the room was kept properly aired.

"April 17. His sores looked tolerably clean, unless on his arms and thighs; where they were livid, a little ulcerated, and discharged a bloody ichor.

"His headach, sickness, &c. were almost gone; his tongue was rather cleaner; pulse 68, and soft. As the decoction of the bark sat easily on his stomach, the following prescription was ordered:

> ℞ Pulv. subtiliss. Cort. Peruv. ʒß. Vini rubri Lusitan. Aquæ fontan. āā ℥ss. M. ft. Haust. tertia quaque hora repetend.

The acidulated drink was continued, and fresh dressings applied to the sores.

"April 18. The little ulcers in his arms and thighs still discharged a bloody ichor, and looked ill; his other complaints were better; pulse 82. The bark had not nauseated him, and it was continued as well as his former drink.

"April 19. His sores looked much cleaner and better; the fever was gone, his pulse natural, and he had no complaint but weakness and a troublesome itching of the skin: The Peruvian bark, &c. were continued.

"April 20. Some of the ulcers still poured forth a bloody ichor; most of them, however, looked well, and had begun to heal—fever gone—medicines continued.

"From the 21st of April, he went on gaining strength, and his sores appeared to heal fast; he was desired to take only four doses every day; and by the 27th his sores, &c. were totally dried up—he had no complaint, and was dismissed cured."

Since the publication of this case of pemphigus by Dr Stuart, observations on this disease have been published by Dr Stephen Dickson of Dublin, in the Transactions of the Royal Irish Academy. In these observations, an account is given of six different cases which Dr Dickson has had an opportunity of seeing. Judging from these, Dr Dickson thinks that Dr Cullen's definition of this disease requires correction; and that it ought to be defined, "a fever accompanied with the successive eruption, from different parts of the body, internal as well as external, of vesicles about the size of an almond, which become turgid with a faintly yellowish serum, and in three or four days subside."

From the cases which have fallen under Dr Dickson's observation, he concludes, that the disease varies considerably as to its mildness or malignity. In three of the cases which he has seen, the symptoms were extremely mild, but in the other three strong symptoms of putrescency were manifested, and the life of the patient was in great danger. With respect to the method of cure, he is of opinion, that the general symptoms of weakness, and tendency to putrefaction, obviously point out the proper treatment. Nourishment must be supplied, and the Peruvian bark and wine carefully administered; and when vesicles appear on internal parts, irritation must be guarded against by opiates, demulcents, and gentle laxatives.

Some additional observations on the subject of pemphigus have lately been published in the London Medical Journal by Mr Thomas Christie. From a case which Mr Christie describes, he is disposed to agree with Mr Dickson in thinking that sometimes at least pemphigus is not contagious. He remarks, however, that the pemphigus described by some foreign writers was extremely infectious; which he thinks may lead to a division of the disease into two species, the pemphigus simplex and complicatus: both of which, but especially the last, seem to vary much with respect to mildness and malignity.

Genus XXXV. APHTHA. 233

The *Thrush*.

Aphtha, *Sauv.* gen. 100. *Lin.* 9. *Sag.* 298. *Boerh.* 978. *Hoffm.* II. 478. *Junck.* 137.
Febris aphthosa, *Vog.* 44.

The only idiopathic species is the thrush to which infants are subject; (Aphtha lactucimen, *Sauv.* sp. 1.)

The aphthæ are whitish or ash-coloured pustules, invading the uvula, fauces, palate, tonsils, inside of the cheeks, gums, tongue, and lips. They for the most part begin at the uvula, sending forth a glutinous mucus, and the pustules covering all or the greatest number of the parts above mentioned, with a thick whitish crust adhering most tenaciously. This crust does not induce an eschar on the parts on which it lies by eating into them, but comes off in whole pieces after the pustules have arrived at maturity. This will often happen in a short time, so that the throat and internal parts of the mouth are frequently observed to be clean, which a few hours before were wholly covered with white crusts. Neither is this disease confined to the throat and fauces, but is said to affect the œsophagus, stomach, and all parts of the alimentary canal. Of this indeed there is no other proof, than that, after a great difficulty of swallowing, there is sometimes an immense quantity of aphthæ evacuated by stool and vomiting, such as the mouth could not be thought capable of containing.

Causes, &c. The aphthous fever seems to be produced by cold and moisture, as it is found only in the northern countries, and especially in marshy places; and in them the aphthæ often appear without any fever at all.

Prognosis. There is no symptom by which the coming out of aphthæ can be foretold, though they are common in many fevers; but they themselves are in general a bad symptom, and always signify a very tedious disorder: the danger denoted by them is in proportion to the difficulty of deglutition; and a diarrhœa accompanying them is likewise bad. This indeed generally carries off old people when they become affected with aphthæ. The dark-coloured aphthæ also are much more dangerous than such as are of a brown or ash colour; but it is a good sign when the appetite returns, and the dark-coloured ones are succeeded by others of a whiter colour. Neither are those which are unaccompanied with fever so dangerous as the other kind.

Cure. As the aphthæ are seldom a primary disease, we must generally endeavour to remove the disorder upon which they depend, after which they will fall off;

Hæmorrhagiæ. off; but in the mean time we are not to neglect applications to the aphthæ themselves, such as detergent and softening gargles made of the decoction of figs, with the addition of honey of roses, a little vinegar, and some tincture of myrrh.

234 ORDER IV. HÆMORRHAGIÆ.

Hæmorrhages.

Hæmorrhagiæ, *Vog.* Class. II. Ord. I. *Hoffm.* II. 194. *Junck.* 5.
Sanguifluxus, *Sauv.* Class IX. Ord. I. *Sag.* Class V. Ord. I.

235 GENUS XXXVI. EPISTAXIS.

Bleeding at the *Nose.*

Hæmorrhagia, *Sauv.* gen. 239. *Lin.* 173. *Sag.* gen. 174.
Hæmorrhagia narium, *Hoffm.* II. 196. *Junck.* 6.
Hæmorrhagia plethorica, *Sauv.* sp. 22. *Hoffm.* II. 198.

The other species enumerated by authors are all symptomatic.

Description. The milder species of this hæmorrhage comes on more frequently in summer than in winter, and for the most part without giving any warning, or being attended with any inconvenience; but the less benign kind is preceded by several remarkable symptoms. These are, congestions of the blood sometimes in one part, and sometimes in another, and which are often very troublesome in the sides of the head: there is a redness of the cheeks; an inflation of the face, and of the vessels of the neck and temples; a *tinnitus aurium;* a heavy pain of the eyes, with a prominence, dryness, and sparks; there is a vertiginous affection of the head, with an itching of the nostrils, and a sense of weight, especially about the root of the nose. In some the sleep is disturbed with dreams about blood, fire, &c. Frequently the belly is costive, there is a diminution of the quantity of urine, a suppression of sweat, coldness of the lower extremities, and tension of the hypochondria, especially the right one.

Causes, &c. This hæmorrhage may occur at any time of life; but most commonly happens to young persons, owing to the peculiar state of the system at that time. Sometimes, however, it happens after the ακμη and during the state of manhood, at which time it is to be imputed to a plethoric state of the system; to a determination of the blood, by habit, to the vessels of the nose; or to the particular weakness of these vessels.

In all these cases the disease may be considered as an arterial hæmorrhage, and depending upon an arterial plethora; but it sometimes occurs in the decline of life, and may then be considered as the sign of a venous plethora in the vessels of the head. It often happens at any period of life in certain febrile diseases, which are altogether or partly of an inflammatory nature, and which show a particular determination of the blood to the vessels of the head. As by this evacuation, other diseases are often removed, it may on these occasions be deemed truly *critical.* It happens to persons of every constitution and temperament; but most frequently to the plethoric and sanguine, and more commonly to men than women.

Epistaxis.

Prognosis. In young people, the bleeding at the nose may be considered as a slight disease, and scarce worth notice. But, even in young persons, when it recurs frequently and in great quantity, it is alarming; and is to be considered as a mark of an arterial plethora, which in the decline of life may give the blood a determination to parts from which the hæmorrhage would be more dangerous; and this will require more particular attention, as the marks of plethora and congestion preceding the hæmorrhage are more considerable, and as the flowing of the blood is attended with a more considerable degree of febrile disorder. These consequences are more especially to be dreaded, when the epistaxis happens to persons after their ακμη, returning frequently and violently. Even in the decline of life, however, it may be considered as in itself very salutary; but at the same time it is a mark of a dangerous state of the system, *i. e.* of a strong tendency to venous plethora in the head, and it has accordingly been often followed by apoplexy, palsy, &c. When it happens in febrile diseases, and is in pretty large quantity, it may generally be considered as critical and salutary; but it is very apt to be too profuse, and thus becomes dangerous. It sometimes occurs during the eruptive fever of some exanthemata, and is in such cases sometimes salutary; but if these exanthemata be accompanied with any putrid disposition, this hæmorrhage, as well as artificial bloodlettings, may have a very bad tendency.

Cure. The treatment in cases of epistaxis may be referred to two heads. 1st, The treatment during the time of the discharge; and, 2dly, The treatment after the discharge is stopt, with the view of preventing the return of it. During the former of these periods, it is necessary in the first place to consider whether the discharge should be left to its natural course, or stopped by artificial means. In determining this question, regard must be paid to the quantity of the discharge; the appearance of the blood; the constitution with which epistaxis occurs; the former habit of the patient; and the consequences which result from the discharge. When, from due consideration of these circumstances, there is reason to fear that further evacuation would be attended with bad consequences, though this disease has been generally thought very slight, it should seldom be left to the conduct of nature; and in all cases it should be moderated by keeping the patient in cool air, by giving cold drink, by keeping the body and head erect, by avoiding any blowing of the nose, speaking, or other irritation; and if the blood has flowed for some time without showing any tendency to stop, we are to attempt the suppression of the hæmorrhage, by pressing the nostril from which the blood flows, washing the face with cold water, or applying this to some other parts of the body. These measures Dr Cullen judges to be proper even on the first attacks, and even in young persons where the disease is in the least hazardous: but they will still be more requisite if the disease frequently recurs without any external violence; if the returns happen to persons not disposed

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disposed to a plethoric habit; and more particularly if no signs of plethora appear in the symptoms preceding the discharge.

When the bleeding is so profuse that the pulse becomes weak and the face pale, every means must be used to put a stop to it, and that whether the patient be young or old. Besides those methods above mentioned, we must use astringents both internal and external; but the latter are the most powerful, and the choice of these may be left to the surgeon. The internal astringents are either vegetable or fossil; but the vegetable astringents are seldom powerful in the cure of any hæmorrhages except those of the alimentary canal. The fossil astringents are more active, but differ considerably in strength from one another.—The chalybeates appear to have little strength: the preparations of lead are more powerful; but cannot be employed, on account of their pernicious qualities, unless in cases of the utmost danger. The *tinctura saturnina*, or *antiphthisica*, is a medicine of very little efficacy, either from the small quantity of lead it contains, or from the particular state in which it is. The safest and at the same time the most powerful astringent, seems to be alum.

For suppressing this and other hæmorrhages, many superstitious remedies and charms have been used, and said to have been employed with success. This has probably been owing to the mistake of the by-standers, who have supposed that the spontaneous cessation of the hæmorrhage was owing to their remedy. At the same time Dr Cullen is of opinion, that such remedies have sometimes been useful, by impressing the mind with horror or dread. Opiates have sometimes proved successful in removing hæmorrhages; and when the fulness and inflammatory diathesis of the system have been previously taken off by bleeding, they may, in Dr Cullen's opinion, be used with safety and advantage. Ligatures have been applied upon the limbs, for retarding the return of the venous blood from the extremities; but their use seems to be ambiguous. In the case of profuse hæmorrhages, no care is to be taken to prevent the patient from fainting, as this is often the most certain means of stopping them.

236 Genus XXXVII. HÆMOPTYSIS.

Spitting of Blood.

Hæmoptysis, *Sauv.* gen. 240. *Lin.* 179. *Vog.* 84. *Sag.* gen. 175. *Junck.* 8.
Hæmoptoë, *Boerh.* 1198.
Sanguinis fluxus ex pulmonibus, *Hoffm.* II. 202.

Sp. I. *Hæmoptysis* from *Plethora.*

Sp. II. *Hæmoptysis* from *External Violence.*

Hæmoptysis accidentalis, *Sauv.* sp. 1.
Hæmoptysis habitualis, *Sauv.* sp. 2.
Hæmoptysis traumatica, *Sauv.* sp. 12.

Sp. III. *Hæmoptysis* with *Phthisis.*

Hæmoptysis phthisica, *Sauv.* sp. 9.
Hæmoptysis ex tuberculo pulmonum, *Sauv.* sp. 10.

Sp. IV. *The Calculous Hæmoptysis.*

Hæmoptysis calculosa, *Sauv.* sp. 14.

Sp. V. *The Vicarious Hæmoptysis.*

Hæmoptysis.

Hæmoptysis catamenialis, *Sauv.* sp. 4.
Hæmoptysis periodica, *Sauv.* sp. 5.

Description. This hæmorrhage commonly begins with a sense of weight and anxiety in the chest, some uneasiness in breathing, pain of the breast or other parts of the thorax, and some sense of heat under the sternum: and very often it is preceded by a saltish taste in the mouth. Immediately before the appearance of blood, a degree of irritation is felt at the top of the larynx. The person attempts to relieve this by hawking, which brings up a little florid and somewhat frothy blood. The irritation returns; and in the same manner blood of a similar kind is brought up, with some noise in the windpipe, as of air passing through a fluid. Sometimes, however, at the very first, the blood comes up with coughing, or at least somewhat of coughing, and accompanies the hawking above mentioned.

The blood is often at first in very small quantity, and soon disappears; but in other cases, especially when it frequently recurs, it is in greater quantity, and often continues to appear at times for several days together. It is sometimes profuse, but rarely in such quantity as either by its excess or by a sudden suffocation to prove immediately mortal.

It is not always easy to discover whether the blood evacuated by the mouth proceeds from the internal surface of the mouth itself, from the fauces or adjoining cavities of the nose, from the stomach, or from the lungs. It is, however, very necessary to distinguish these different cases; and for this Dr Cullen offers the following considerations.

1. When the blood proceeds from some part of the internal surface of the mouth, it comes out without any hawking or coughing; and generally, upon inspection, the cause is evident.

2. When blood proceeds from the fauces, or adjoining cavities of the nose, it may be brought out by hawking, and sometimes by coughing. In this case, there may be a doubt concerning its real source, and the patient may be allowed to please himself with the thoughts that the blood does not come from the lungs. But the physician must remember that the lungs are much more frequently the source of a hæmorrhage than the fauces. The latter seldom happens but to persons who have before been liable to a hæmorrhage from the nose, or to some evident cause of erosion; and in most cases, by looking into the fauces, the distillation of the blood from thence will be perceived.

3. When blood proceeds from the lungs, the manner in which it is brought up will commonly show from whence it comes; but, independent of that, it may also be known from the causes of hæmoptysis from the lungs, to be afterwards mentioned, having preceded.

4. When vomiting accompanies the throwing out of blood from the mouth, we may generally know the source from whence it proceeds, by considering that blood does not proceed so frequently from the stomach as from the lungs: that blood proceeding from the stomach commonly appears in greater quantity than from the lungs. The pulmonary blood also is usually of a florid colour, and mixed with a little frothy mucus

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mucus only; but the blood from the stomach is of a darker colour, more grumous, and mixed with the other contents of the stomach. The coughing or vomiting, as the one or the other happens first to arise, may sometimes point out the source of the blood; and this has also its peculiar antecedent signs and causes.

Causes, &c. A hæmoptysis may be produced at any time of life by external violence; and, in adult persons, while the arterial plethora prevails in the system, i. e. from the age of 16 to 35, a hæmoptysis may at any time be produced merely by a plethoric state of the lungs. More frequently, however, it arises from a faulty proportion between the capacity of the lungs and that of the rest of the body. Thus it is often an hereditary disease, which implies a peculiar and faulty conformation.

This disease especially happens to persons, who discover the smaller capacity of their lungs by the narrowness of their chest, and by the prominence of their shoulders; which last is a mark of their having been long liable to a difficulty of respiration. In such cases, too, the disease very frequently happens to persons of a sanguine temperament, in whom particularly the arterial plethora prevails. It happens also to persons of a slender delicate make, of which a long neck is a mark; to persons of much sensibility and irritability, and therefore of quick parts; to persons who have formerly been liable to hæmorrhages from the nose: to those who have suffered a suppression of any usual hæmorrhage, the most frequent instance of which is in females who have suffered a suppression of their menstrual flux; and, lastly, to persons who have suffered the amputation of a limb.

All this constitutes the predisponent cause of hæmoptysis; and the disease may happen merely from the predisponent cause arising to a considerable height. But in those who are already predisposed, it is often brought on by the concurrence of various occasional and exciting causes. One of these, and perhaps a frequent one, is external heat; which, even when in no great degree, brings on the disease in spring, and the beginning of summer, while the heat rarefies the blood more than it relaxes the solids, which had before been contracted by the cold of winter. Another exciting cause is a sudden diminution of the weight of the atmosphere, especially when concurring with any effort in bodily exercise. The effort alone, may often be the exciting cause in those who are already predisposed; and more particularly any violent exercise of respiration. In the predisposed, also, the disease may be occasioned by any degree of external violence.

Prognosis. Hæmoptysis may sometimes be no more dangerous than a hæmorrhage from the nose; as when it happens to females, in consequence of a suppression of their menses; when, without any marks of predisposition, it arises from external violence; or, from whatever cause it may proceed, when it leaves no cough, dyspnœa, or other affection of the lungs, behind it. But, even in these cases, a danger may arise from too large a wound being made in the vessels of the lungs, from any quantity of red blood being led to stagnate in the cavity of the bronchiæ, and particularly from any determination of the blood being made into the vessels of the lungs, which by renewing the hæmorrhage may have these consequences.

Hæmoptysis.

Cure. In the treatment of this disease, with a view of stopping the discharge, it is first necessary to have recourse to those measures which tend to diminish the impetus by which the blood is expelled. This is to be effected by a removal of plethora when it exists; by diminishing the general impetus of circulation; by diminishing local increased action when it takes place in the vessels of the lungs; and by producing a determination of blood to other parts of the system remote from the lungs. But besides practices diminishing impetus, it is often also necessary to employ such as augment the resistance to the passage of blood through the ruptured vessels of the lungs. With these views a variety of practices may be employed, particularly blood-letting, refrigerants, sedatives, astringents, and the like.

On this subject Dr Cullen differs from those who prescribe chalybeates and cinchona in the cure of hæmoptysis. Both of these, he observes, contribute to increase the phlogistic diathesis then prevailing in the system, and the hæmoptysis from predisposition is always accompanied with such a diathesis. Instead of these, therefore, he recommends blood-letting in greater or smaller quantity, and more or less frequently repeated as the symptoms shall direct. At the same time cooling purgatives are to be employed, and every part of the antiphlogistic regimen is to be strictly enjoined. In the London Medical Observations, the use of nitre is greatly recommended by Dr Dickson, to whom its efficacy was made known by Dr Letherland, physician to St Thomas's Hospital. The most commodious method of exhibiting it he found was in an electuary. Four ounces of conserve of roses were made into an electuary with half an ounce of nitre; of which the bulk of a large nutmeg was directed to be given, four, six, or eight times a day, according to the urgency of the case. The good effects of this, he tells us, have often astonished him: and when given early in the disease, he says he can depend as much upon it for the cure of an hæmoptysis, as on cinchona for the cure of an intermittent. He agrees with Dr Cullen, however, that in those cases where there is any hardness in the pulse, and which almost always happens, there is a necessity for venesection. A cool regimen, and quiet of body and mind, are certainly useful; but Dr Cullen observes that some kinds of gestation, such as sailing, and travelling in an easy carriage on smooth roads, have often proved a remedy. When the cough is very troublesome, it is absolutely necessary to exhibit frequently a small dose of an opiate. Dr Dickson also informs us, that the nitre joined with spermaceti, or *pulv. è tragacanth. comp.* has produced equally good effects with the electuary above mentioned; in the composition of which he at first considered the conserve only as a vehicle for the nitre, though he means not to insinuate that the former is totally destitute of efficacy.

When this hæmorrhage has resisted other modes of cure, and there is reason to apprehend, even from the mere quantity of blood evacuated, that the patient may sink under the discharge, blisters, particularly when applied to the breast, are often had recourse to with great advantage; and the sulphuric acid, properly diluted, mor- giæ. luted, both as an astringent and refrigerant, is often employed with very good effects.

37 ## PHTHISIS.

Pulmonary Consumption.

Phthisis, *Sauv.* gen. 276. *Lin.* 208. *Vog.* 319. *Sag.* 101. *Junck.* 33.
Phthisis pulmonis, *Boerh.* 1196.
Affectio phthisica, sive tabes pulmonalis, *Hoffm.* II. 284.

38 Sp. I. The *Incipient Phthisis*, without expectoration of *Pus*.

Phthisis incipiens, *Morton* Physiolog. L. II. cap. 3.
Phthisis sicca, *Sauv.* sp. 1.

39 Sp. II. The *Confirmed Phthisis*, with an expectoration of *Pus*.

Phthisis confirmata *auctorum*.
Phthisis humida, *Sauv.* sp. 2.

Sometimes, notwithstanding all the care that can be taken, the hæmoptysis will degenerate into a phthisis pulmonalis, or consumption of the lungs; and sometimes hæmoptysis will be the consequence of this dangerous disorder. It has indeed been supposed, that an ulceration of the lungs, or phthisis, was the natural and almost necessary consequence of hæmoptysis: but according to Dr Cullen, this is in general a mistake; for there are many instances of a hæmoptysis from external violence without being followed by any ulceration. The same thing has often been observed where the hæmoptysis arose from an internal cause; and this not only in young persons, when the disease returned for several times, but when it has often recurred during the course of a long life; and it may easily be conceived, that a rupture of the vessels of the lungs, as well as of the vessels of the nose, may be sometimes healed. The causes of phthisis, therefore, Dr Cullen reduces to five heads. 1. A hæmoptysis. 2. A suppuration of the lungs in consequence of a pneumonia. 3. A catarrh. 4. An asthma; and, 5. Tubercles.

1. When a phthisis arises from a hæmoptysis, it is probable that it is occasioned by particular circumstances; and what these circumstances are, may not always be easily known. It is possible, that merely the degree of rupture, or frequently repeated rupture, preventing the wound from healing, may occasion an ulcer; or it is possible, that red blood effused, and not brought up entirely by coughing, may, by stagnating in the bronchiæ, become acrid, and erode the parts. But these hypotheses are not supported by any certain evidence; and from many observations we are led to think, that several other circumstances must concur in producing the disease from hæmoptysis.

2. The second cause of an ulceration of the lungs mentioned above is a suppuration formed in consequence of pneumonia. When a pneumonia, with symptoms neither very violent nor very slight, has continued for many days, it is to be feared it will end in a suppuration; but this is not to be determined by the number of days; for, not only after the fourth, but even after the tenth day, there have been examples of a pneumonia ending by a resolution; and if the disease has suffered some intermission, and again recurred, there may be instances of a resolution happening at a much later period from the beginning of the disease than that now mentioned. But if a moderate disease, in spite of proper remedies employed, be protracted to the 14th day without any considerable remission, a suppuration is pretty certainly to be expected; and it will be more certain still, if no signs of resolution have appeared, or if an expectoration which had appeared shall have agained ceased, and the difficulty of breathing has continued or increased, while the other symptoms have been rather abated. Phthisis.

That in a pneumonia, the effusion is made which may lay the foundation of a suppuration, may be concluded from the difficulty of breathing becoming greater when the patient is in a horizontal posture, or when the patient can lie more easily on the affected side. That, in such cases, a suppuration is actually begun, may be inferred from the patient's being frequently affected with slight cold shiverings, and with a sense of cold felt sometimes in one sometimes in another part of the body. We form the same conclusion also from the state of the pulse, which is commonly less frequent and softer, but sometimes quicker than before. That a suppuration is already formed, may be inferred from there being a considerable remission of the pain which had before subsisted; while with this the cough, and especially the dyspnœa, continue, and are rather increased. At the same time the frequency of the pulse is rather increased, the feverish state suffers considerable exacerbations every evening, and by degrees a hectic fever in all its circumstances comes to be formed.

In this state of symptoms, we conclude very confidently, that an abscess, or, as it is called, a *vomica*, is formed in some part of the pleura, and most frequently in that portion of it investing the lungs. Here purulent matter frequently remains for some time, as if enclosed in a cyst; but commonly not long before it comes to be either absorbed and transferred to some other part of the body, or breaks through into the cavity of the lungs, or into that of the thorax. In the latter case it produces the disease called *empyema;* but it is when the matter is poured into the cavity of the bronchiæ that it properly constitutes the phthisis pulmonalis. In the case of empyema, the chief circumstances of a phthisis are indeed also present: but we shall here consider only that case in which the abscess of the lungs gives occasion to purulent expectoration.

An abscess of the lungs, in consequence of pneumomia, is not always followed by a phthisis: for sometimes a hectic fever is not formed; the matter poured into the bronchiæ is a proper and benign pus, which frequently is coughed up very readily, and spit out; and though this purulent expectoration should continue for some time, if it be without hectic fever, the ulcer soon heals, and every morbid symptom disappears. This has so frequently happened, that we may conclude, that neither the access of the air, nor the constant motion of the lungs, will prevent an ulcer of these parts from healing, if the matter of it be well-conditioned. An abscess of the lungs, therefore, does not necessarily produce phthisis pulmonalis; and if it be followed by such a disease, it must be in consequence of particular circumstances which corrupt the purulent

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purulent matter produced, render it unsuitable to the healing of the ulcer, and at the same time make it afford an acrimony, which, absorbed, produces a hectic fever and its consequences.

The corruption of the matter of such abscesses may be owing to several causes; as, 1. That the matter effused during the inflammation had not been a pure serum fit to be converted into a laudable pus, but had been joined with other matters which prevented that, and gave a considerable acrimony to the whole. Or, 2. That the matter effused and converted into pus, merely by long stagnation in a vomica, or by its connexion with an empyema, had been so corrupted as to become unfit for the purpose of pus in the healing of the ulcer. These seem to be possible causes of the corruption of matter in abscesses, so as to make it the occasion of a phthisis in persons otherwise sound; but it is probable that a pneumonic abscess especially produces phthisis when it happens to persons previously disposed to that disease, and therefore only as concurring with some other causes of it.

3. The third cause supposed to produce a phthisis is a catarrh; which, in many cases, seems in length of time to have the expectoration of mucus proper to it gradually changed to an expectoration of pus; and at the same time, by the addition of a hectic fever, the disease, which was at first a pure catarrh, is changed into a phthisis. But this supposition is, in the opinion at least of some physicians, liable to several difficulties. The catarrh is properly an affection of the mucous glands of the trachea and bronchiæ, analogous to the coryza and less violent kinds of cynanche tonsillaris, which very seldom end in suppuration. And although a catarrh should be supposed to do so, the ulcer produced might readily heal up, as it does in the case of a cynanche tonsillaris; and therefore should not produce a phthisis.

Farther, The catarrh, as purely the effect of cold, is generally a mild disease as well as of short duration; and, according to Dr Cullen, there are at most but very few of the numerous cases of it, which can be said to have ended in a phthisis. In all these cases in which this seems to have happened, he thinks it probable that the persons affected were peculiarly predisposed to phthisis; and the beginning of phthisis so often resembles a catarrh, that it may have been mistaken for such a disease. It often happens also, to increase the fallacy, that the application of cold, which is the most frequent cause of catarrh, is also frequently the exciting cause of the cough, which proves to be the beginning of a phthisis.

Many physicians have supposed that an acrimony of the fluids eroding some of the vessels of the lungs is a frequent cause of ulceration and phthisis; but this appears to Dr Cullen to be a mere supposition. He acknowledges, that in many cases in acrimony subsisting in some part of the fluids is the cause of the disease; but observes that it is at the same time probable, that this acrimony operates by producing tubercles, rather than by any direct erosion.

But, notwithstanding these objections, experience affords numerous examples of cases in which a disease long subsisting under the form of catarrh has at last degenerated into phthisis, and proved fatal from supervening hectic fever. It must, however, at the same time be allowed, that catarrh, degenerating into a chronic state after subsisting for many years, has of itself often proved fatal without inducing phthisis.

Phthisis.

4. If phthisis does not frequently follow catarrh, it is still more rarely a consequence of asthma. Innumerable examples are unquestionably afforded of that disease subsisting for many years without any symptom whatever of phthisis as a consequence of it. But, at the same time, there are unquestionable examples of phthisis deriving its origin from asthma; which, however, probably happens only in cases where a peculiar state of the lungs at the same time takes place. But, without the concurrence of asthma, this state would not of itself have been sufficient for inducing the affection.

5. Of all the causes formerly mentioned, phthisis most frequently arises from tubercles. Dr Simmons informs us, that he has had opportunities of inspecting the bodies of many people who died in this way, and never found them totally absent. He has likewise seen them in subjects of different ages, who had been troubled with no symptoms of an affection of the breast during their lifetime. In these, however, they were small, and few in number. This proves that they may exist without inconvenience till they begin to disturb the functions of the lungs by their size and number; or till some degree of inflammation be excited, either by accidental causes, or by certain changes that take place within their substance; for as yet we know but little of their true nature. These little tumours vary in their consistence; in some they are composed of a pulpy substance, and in others approach more to the nature of scirrhus. They are most commonly formed in consequence of a certain constitutional predisposition; but whatever is capable of occasioning a morbid irritability of the lungs seems also to be capable of generating them. Thus the spasmodic asthma frequently ends in tubercles and consumption; and it is not unusual for millers, stone-cutters, and others, to die consumptive, from their being so constantly exposed to dust, which in these cases probably acts by producing similar concretions. Dr Kirkland observes, that scythe-grinders are subject to a disease of the lungs, from particles of sand mixing with iron dust, which among themselves they call the *grinders rot*. Tubercles, however, in by much the greater number of instances, have their source from a scrophulous disposition; and some eminent physicians have supposed that the generality of pulmonary consumptions are of this kind. This notion, however, they have perhaps carried too far: they have probably been misled by those tuberculous concretions which, without good reason, have been supposed to be diseased glands, and of course analogous to the glandular affections we meet with in the scrophula. Tubercles may likewise sometimes be owing to the sudden repulsion of cutaneous eruptions, or of the matter of exanthemata, &c. or to other causes.

The persons who are most liable to consumption are those of a fair complexion, fine and soft skin, florid cheeks, and a slender make; with high cheek-bones, hollow temples, long neck, shoulders standing out like wings, narrow chest, and a remarkable prominence of the processes of the os sacrum. To these marks we may add, that of *sound teeth*, which, as the disease advances,

vances, usually become of a milky white colour, and more or less transparent. Of those who are carried off by this disease, Dr Simmons asserts, the greater number will be found never to have had a carious tooth. This circumstance, however, does not seem to us to hold so generally as Dr Simmons is disposed to imagine: and instances not unfrequently occur of patients dying of phthisis, although they have had many teeth subjected to caries; and some of these beginning even at an early period of life.

Persons of the above description often remain for a long time without feeling any other inconvenience than some oppression at the breast in moist weather, or in hot apartments. Their breathing is easily hurried, sometimes by the slightest motion; and they become languid, paler, and thinner. All this time, however, they feel no heat or painful sensation in the breast. As the evil increases, the patient begins to be attacked with a slight, frequent, and dry cough, which is most troublesome in the night time. But this, by proper care, is often relieved; and the patient remains in this state for a considerable time, and even for many years, if he be sensible of his danger, and careful to guard against it by a suitable manner of living. More commonly, however, we find the cough increasing, and sometimes accompanied with more or less catarrh. This is usually ascribed to cold; and but too generally neglected, till the disease becomes alarming by its obstinacy and its effects. This may be considered as the *beginning*, or first period, of the disease. During this stage, the cough is sometimes dry from the first: and sometimes when it begins in the form of a catarrh, is attended with more or less expectoration of mucus.

When the cough begins in the form of a catarrh, and appears to be occasioned by an increased secretion of a thin saltish mucus irritating the membrane of the trachea, all judicious practitioners agree in recommending an attention to regimen, the free use of diluting liquors, bland emulsions, small doses of nitre, the taking away a few ounces of blood if there be much inflammation, the inhaling the steams of warm water by means of the machine contrived for that purpose, and the occasional use of such a dose of elixir paregoricum as will be sufficient to allay the irritation of the bronchiæ, and to promote a general moisture on the skin. These methods will generally be found to be efficacious, especially if the patient's chamber be of a moderate temperature, and he carefully avoid exposure to a cold, damp, or raw air, till the complaint be removed. In cases in which the cough has been obstinate, and the inflammatory symptoms considerable, Dr Simmons has often experienced the great advantages of the warm bath, the heat of which did not exceed 92°. When this is had recourse to, the patient should remain in it only a very few minutes, and go soon afterwards to bed; but not with a view to force a sweat by an increased weight of bedclothes, as is too often injudiciously practised.

Patients of a consumptive habit, who have had an attack of this kind at the beginning of winter, are particularly liable to a return of the complaint during the continuance of the cold season, on the slightest occasion and with greater violence. A relapse is therefore to be carefully guarded against; and nothing will be found to do this more effectually than the use of socks and a flannel under-waistcoat. The use of flannel has been condemned by several medical writers as increasing the insensible perspiration; but in the present case, to say nothing of some others in which it may be useful, it will in general be found to have the best effects. It will prevent a too great determination to the lungs, and should not be left off till the approach of summer. In some few instances in which flannel was found to have a disagreeable effect, a piece of dimity worn over the breast next the skin, will prevent the return of colds and coughs in persons of a delicate habit, who had before been liable to them on the slightest occasions. Shirts made of cotton cloth are much more effectual than linen in preserving an equable temperature of the surface, and guarding against the action of external cold; while at the same time they are much more pleasant to most people than even the finest flannel. In these cases, circumstances that are seemingly of the most trifling nature become of importance.

Sometimes the cough is occasioned by an immediate inflammation of some part of the lungs, from some of the usual causes of inflammation; and when this happens, no time is to be lost in removing it. To do this will perhaps require more than one bleeding, together with a strict attention to a cooling plan of diet, diluting drinks, the inhalation of warm steams, and if convenient, the use of the warm bath; but, above all, the speedy application of a large blister as near as may be to the supposed seat of the inflammation. The cough, in this case, will often remain after the original complaint is abated. A prudent use of opiates at bedtime, either by themselves or combined with gummy and mucilaginous medicines, will then generally be useful as a sedative and antispasmodic.

In this, as well as in the catarrhal cough just now mentioned, many practitioners are too eager to administer cinchona, with the view, as they term it, of *bracing* up the patient: but this never fails to increase the cough, and of course to do great and very irreparable mischief.

And here it will not be foreign to our subject to observe, that a symptomatic cough, which has its rise not from catarrh, or from an immediate inflammation of the lungs, but from their sympathy with the stomach, has sometimes laid the foundation of phthisis, from its having been mistaken, and of course improperly treated. It seems to be owing to a redundancy or vitiated state of the bile, or to some affection of the stomach, which it is perhaps not easy to define. It is sometimes a concomitant of other bilious symptoms; and when this happens to be the case, it cannot easily be mistaken; but we sometimes find it occurring singly, and in general attacking persons of a sedentary life. Dr Stoll of Vienna, who has noticed this cough, has very properly given it the name of *tussis stomachica*. This complaint is so far from being relieved by bleeding, that it constantly grows worse after it, especially if the evacuation be in any considerable quantity. The oily remedies seldom fail to exasperate this cough, which at first is dry, frequent, and often extremely violent, but which seldom fails to give way to one or two gentle pukes, and the occasional use of mild cathartics. The cough, as in other cases, often continues from habit after the cause that

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that gave rise to it has been removed, and may then be checked by opiates.

When the disease has been neglected, or our attempts to remove it in the beginning have failed, both of which circumstances but too frequently happen, the patient begins to complain of a soreness, and of slight lancinating pains shooting through the breast, sometimes in the direction of the mediastinum, and sometimes confined chiefly to one side. The soreness is pretty constant, and much increased by the cough. The pain in the side often prevents the patient from lying on the side affected; and this inability of lying except on one side, frequently occurs even when no such pain is felt. In this stage of the disease, flushing heats are felt on the palms of the hands and soles of the feet: the breathing is short and laborious; and it is not long before the patient begins to expectorate a thin and frothy phlegm, at first in small quantities, coughed up with difficulty, and some pain of the breast, and now and then streaked with blood: this may be considered as the *inflammatory period* of the disease, to which succeeds the *suppurative stage.* In the latter, the expectoration becomes more copious and purulent, the breath proportionably offensive, and the exacerbations of the hectic fever more considerable: an increased quickness of the pulse comes on about the middle of the day; but the most considerable paroxysm of the fever is at night, and at first continues till towards morning, commonly till three or four o'clock, when it terminates in a sweat, which usually begins upon the breast. As the disease advances, these sweats become more profuse, and sometimes come on almost as soon as the pulse begins to quicken, but without affording any relief to the patient. During the exacerbations, we observe a circumscribed redness of the cheeks, while the rest of the face is pale, and appears as if it were not clean washed. The costiveness that commonly accompanies the beginning of the disease is usually succeeded by a diarrhœa; the spitting lessens, and all the purulent matter seems to be carried downwards. The wasting of the fat and the loss of nourishment occasion the nails to curve inwards, the hair to fall off, and the eyes to sink in their sockets. In the mean time, the legs commonly swell; till at length death closes a scene which is melancholy to all but the patient himself, who in general continues sensible to the last moment, and even then indulges a vain hope of prolonging a miserable existence. In some cases, and that not unfrequently, a delirium comes on towards the close of the disease.

The hectic fever that attends this and some other chronic diseases, is evidently the effect of acrimony, and most commonly of pus absorbed and carried into the circulation. The nature of this acrimony, and the different irritability of different patients, are probably the sources of the variety we observe in fevers of this denomination; a variety which is doubtless much greater than we are aware of. Thus we find that the matter of the smallpox excites a fever of this kind; but this *secondary fever*, as it is called, differs from the hectic attendant on consumptions; nor does the latter correspond with that which sometimes accompanies the suppuration of a cancerous ulcer. In the pulmonary consumption, or at least in the third stage of it, the fever induced often appears to be of the putrid kind, and has been denominated *febris hectica putrida* by the judicious Morton, who considers it as being combined with a peripneumonic or inflammatory fever, which recurs as often as fresh tubercles begin to inflame. For although we have named one period of the disease the *inflammatory*, and another the *suppurative period*, yet we are not to suppose that the latter is exempt from inflammation. While matter is poured into the bronchiæ, or absorbed and carried into the system from one part of the lungs, other parts are in a crude state of inflammation, or advancing towards suppuration; so that, on examining the lungs of persons who die consumptive, we find some tubercles that are small and just formed, some that are large and full of matter, and others that are in a state of ulceration. This easily accounts for the occasional combination of inflammatory symptoms with those of the putrid hectic. When the matter absorbed is a laudable pus, as in the case of the psoas abscess, we find the form of the hectic fever differing from either of those we have mentioned.

Phthisis.

Cure. In these different periods of the disease, the curative indications are sufficiently obvious. To prevent the formation of fresh tubercles; to obviate the inflammation of those already formed; to promote their resolution; to allay morbid irritability, the cough, and other troublesome symptoms; and, above all, to check the tendency to the hectic state, are the views that every rational physician proposes to himself in the treatment of the genuine consumption. We know of no medicines that can exert their specific effects upon the lungs by dissolving tuberculous concretions; nor is it probable, from what we know of the animal economy, that any such will ever be discovered. Yet medicines that operate in a general manner upon the system, may, by promoting absorption, and diminishing the determination to the lungs, tend to disperse tubercles, or to prevent their formation. There are not wanting instances of wonderful recoveries, in cases where the evil was supposed to be beyond the power of physic; and in some, where nature was left to herself; so that a physician who has observed the various and powerful resources nature has within herself, will be very cautious how he asserts that a disease is incurable.

The most formidable effects of ulcerated lungs are the absorption and consequent hectic. It seems evident, that, in many cases, death is brought on by this, rather than by the lungs themselves being rendered unfit for the purposes of respiration. So that if we can obviate the effects of the absorption, diminish the preternatural determination to the lungs, and fulfil the other general indications just now mentioned, we may very often enable nature to recover herself. It may be alleged, indeed, that the physicians art has hitherto proved very unsuccessful in these cases; but may not this be owing to the remedies that are employed being very often such as are inimical to the cure?

The cinchona is, perhaps, the most commonly employed of any, and often confided in as an ultimate resource in these cases. But besides this, the sulphuric acid, the balsams, and frequent bleeding, have each had their partizans. The use of blisters and issues, opiates, a milk and vegetable diet, exercise, and change of air, are pretty generally recommended by all. Concerning cinchona, Dessault long ago observed, that it had been productive

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productive of great mischief in consumptive cases; and Dr Fothergill, in a paper lately published by him on this subject, very judiciously remarks, that it is so far from curing the hectic fever arising from distempered lungs, that according to the best of his observations, it not only takes up that time which might probably have been better employed in the use of other medicines, but for the most part aggravates the disease beyond remedy. Indeed it has been the opinion of several attentive observers, that whenever pus or any kind of matter excites an hectic fever, by being absorbed and carried into the circulation, the cinchona will never fail to exasperate the complaint, especially if it be accompanied with any degree of inflammatory diathesis, unless the matter has a free outlet from the system; as in the case of abscesses, for instance, in which we often find it productive of excellent effects. It is likewise well known to be used as a tonic, to obviate the effects of fluor albus, or any other immoderate evacuation in delicate persons, which, by enfeebling the system, very often lays the foundation of phthisis: but the moment we have reason to suspect that the lungs are ulcerated, especially if this ulceration be attended with an inflammatory disposition; or if the separation of vitiated pus be the consequence of a peculiar increased morbid action of the vessels at the part, it ought to be laid aside; and in the genuine tuberculous consumption, perhaps, it is rarely admissible.

Dr Fothergill, however, observes, that there are two causes of consumption, which often produce symptoms so similar to those of the genuine phthisis, as sometimes to have led him to make use of cinchona, in apparent tendencies to a genuine pulmonary consumption, with advantage.

One of the causes is, the suckling of children longer than is consistent with the mother's ability. This case frequently occurs among the middling and lower classes of females, of constitutions naturally delicate and tender. In such a state of weakness, some slight cold brings on a cough, which increases gradually, till at length it produces the true pulmonary consumption. Here cinchona given early, in moderate doses, and merely as a tonic remedy, is often of excellent use.

Another cause, is any weakening discharge, either from abscesses, the greater operations of surgery, a copious and constant *fluor albus*, or similar enfeebling evacuations. That cinchona is, for the most part, of use in these cases, when the lungs are not inflamed, is indubitable; and if they be so affected, but not beyond a certain degree, it is also efficacious in preventing the progress of the consumption.

In phthisical complaints succeeding such situations, a prudent trial of cinchona seems necessary. Small doses of the decoction, either alone, or joined with the saline mixture or such other additions as the physician thinks proper, may be given. But if the breath becomes more tight and oppressed, the cough dry, the pulse more quick and hard, and especially if slight transitory pains or stitches about the thorax are more frequently complained of, a perseverance in the use of cinchona will increase the disease. If such also should be the appearances in the progress of the disease, or, from whatever cause, if cinchona be accompanied with such effects, the use of it ought to be withheld.

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If, on the other hand, no pain, tightness, or oppression, is perceived, and there appear a manifest abatement of the symptoms, it will be adviseable to proceed. The administration of this medicine, however, requires a judicious observer; and it ought neither to be given in the early inflammatory stage of this disease, nor be continued in any subsequent period, if it produce the effects above mentioned.

By its tonic virtues it will often enable nature to conquer many difficulties. In confirmation of this remark, Dr Fothergill farther observes, that he has seen it of use in promoting expectoration, when this became deficient from want of strength towards the end of peripneumonic fevers; but that it stops this discharge, changes slight wandering pains into such as are fixed, and increases them with all their consequences, in a variety of cases.

The elixir of vitriol, or the sulphuric acid properly diluted, though in many instances a highly useful remedy, is often exhibited in consumptive cases with no less impropriety than cinchona. This medicine, from its astringency, is obviously improper in the inflammatory state of the disease. But in the latter stage, when a general tendency to putrefaction takes place, it is serviceable in resisting the effect; it restrains the colliquative sweats; and if the lungs be not injured past reparation, it is allowed to be a very useful auxiliary.

Various are the opinions concerning the efficacy of Bristol water in this disease. The experienced author last mentioned informs us, that he has seen many persons recover from pulmonary diseases after drinking these waters, whose cure seemed to be doubtful from any other process; and he thinks this circumstance, added to the general reputation of Bristol waters in phthisical cases, affords sufficient inducement to recommend the trial of them in the early stages of such complaints. It is, however, before the approach of a confirmed phthisis that patients ought to repair to Bristol; otherwise a journey thither will not only be without benefit, but may even prove detrimental.

Some have imagined, that the journey, a better air, change of situation and of objects, have contributed to the patient's recovery; and these may doubtless be of advantage. It seems, however, that the water drank fresh at the pump, actually contains principles conducive to the recovery of patients affected with phthisical complaints. It seems to possess a slight calcareous stypticity, and perhaps the air it contains may also have an antiseptic quality. On the whole, it appears to be an efficacious medicine, and is often found of remarkable benefit to consumptive patients.

Change of air, particularly from bad to good, is of great consequence to all chronic diseases of the lungs. In consumptive cases, the air of all large cities is found to be particularly injurious.

A sea voyage has been much recommended in the cure of this disease. The benefit of exercise has also been strongly urged by many writers; but, however salutary when properly used, it certainly ought to be regulated with discretion. Dr Dickson declares himself of opinion, that riding on horseback in consumptive cases is most commonly hurtful, without such regulations as

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as in general have been little regarded. For instance, he has known a person who, by a ride of an hour or two in the morning, was very much recruited, and who, at another time, in the afternoon and evening, without undergoing more bodily motion, has returned faint and languid, and apparently worse. This observation on the same person has been so frequently made, as to point out clearly the times when this exercise shall not do hurt in consumptive cases. In this disease, the pulse, however calm in the morning, becomes more frequent in the afternoon and night, attended with heat and other feverish symptoms. Exercise therefore, at this time, can only add to the mischief of the fever. For this reason he prudently recommends to all hectic persons, especially those who shall travel to distant places on account of a better air, or the benefit expected from any particular water, that their travelling should be slow, confined to a very few hours, and only in the morning.

Exercise on horseback seems to be chiefly beneficial in those cases where consumption is a secondary disease. For example, in the nervous atrophy; in the hypochondriacal consumption; or when it is the effect of long-continued intermittents, or of congestions in any of the abdominal viscera; or, in a word, whenever the consumption is not attended with an inflamed or ulcerated state of the lungs, long journeys on horseback will be beneficial. Such a practice may likewise be highly useful in obviating an attack of phthisis, or in carrying off a dry husky cough in a person of a consumptive habit, when there is reason to suppose that no tubercles are as yet formed. On the other hand, in the confirmed phthisis, when the lungs are inflamed or ulcerated, much or violent exercise will be improper; and there have been instances where the death of the patient was evidently accelerated by it. The exercise therefore should be gentle, proportioned to the strength of the patient, and employed only in the morning. In fine weather, an easy open carriage is perhaps the most eligible, not only on account of its being open to the air, but because it affords that kind of agitation which is most wanted in these cases. For if we consider the different modes of exercise, we shall find that walking, though the best exercise in health, as it employs the most muscles, is the worst for the sickly, who should have the benefit of exercise without fatigue. Riding on horseback agitates the viscera more than walking, and is therefore preferable to it in many chronic diseases; but when a preternatural determination to the lungs has taken place, it will be liable to increase the evil, and may likewise be hurtful by the fatigue that attends it. For these reasons it will be prudent to begin with a carriage; and if the patient gain strength, and the disease abates, recourse may afterwards be had to horse-exercise.

The gentle motion of a coach has been often found of great utility in pulmonary complaints. Its efficacy seems to depend chiefly on its increasing the determination to the surface of the body. The nausea which this motion excites in some persons is an effect of this increased determination. It has therefore been found beneficial in hæmoptysis; and Dr Simmons mentions the case of a lady, who, after trying various remedies to no purpose, was cured of this complaint by travelling several hundred miles through different parts of England in her own coach. At first, whenever she remained three or four days in any place, the disorder began to return again; but at length by persevering in her journeys, it gradually went off. Dessault, who practised at Bourdeaux about 40 years ago, tells us, he sent several consumptive patients to Bareges, and with good success; but that in these cases his reliance was not so much upon the Bareges waters, as upon the motion of the carriage and the change of air in a journey of more than 100 leagues.

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It is now pretty generally acknowledged, that the good effects of sea voyages in consumptive cases depend more upon the constant and uniform motion of the ship, than upon any particular impregnation of the sea air; although this from its coolness and purity may likewise be of great use, especially in the hot months, when sea voyages are generally undertaken by consumptive patients. The ancients were no strangers to this remedy; and amongst the Romans it was no unusual thing for consumptive persons to sail to Egypt. Pliny observes, that this was not done for the sake of the climate, but merely on account of the length of the voyage.

Many of our English physicians have recommended a voyage to Lisbon in these cases. When this is done, the proper season of the year should be carefully attended to. Dr Simmons knew a gentleman who went thither with symptoms of incipient phthisis, and who experienced some relief during the course of the voyage; but happening to arrive at Lisbon at the beginning of the rainy season, the disease was soon greatly increased, and terminated fatally.

Another species of motion has of late been extolled as highly useful in consumptive cases. Dr James Carmichael Smyth of London, has lately published an account of the effects of swinging, employed as a remedy in the pulmonary consumption and hectic fever. In this treatise Dr Smyth contends, that sea air, in place of being of advantage, is constantly prejudicial to hectic and consumptive patients, and even to those who have a tendency to such complaints. He thinks, therefore, that the benefit derived from sea voyages must certainly be referred to some other cause. In stating his sentiments on this subject, he attempts to establish a distinction between exercise and motion. By exercise, he understands muscular action, or the exertion of the locomotive powers of the body either alone or combined. This he represents as increasing the force and frequency of the heart's contraction, the velocity and momentum of the blood, the quickness of breathing, the heat, the irritability, and the transpiration of the whole body. By motion, in contradistinction to exercise, he means such motion as is not necessarily accompanied with any agitation or succussion of the body, and which is totally independent of any muscular exertion. The effects of this, both on the heart, the lungs, and indeed on the system in general, he considers as of the sedative kind; thus it suspends the action of coughing, and lessens the frequency of the pulse. He is, therefore, led to refer the good effects of sea voyages entirely to this cause. And on these grounds he was led to conclude, that the motion given by swinging might be of equal if not greater service. This conclusion, we are told, in the treatise above alluded to, experience in many

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cases has fully confirmed; and he recommends it as a mode of cure which may be employed with advantage in every stage of phthisis. While, however, the reasoning of Dr Smyth on this subject seems to be liable to many objections, we are sorry to add, that his observations in practice have by no means been confirmed by those of others, who have had recourse to this mode of cure.

The best adapted diet in consumptive cases is milk; the milk of asses, both as an article of diet and as a medicine, has in particular been highly extolled. It may however be remarked, that there are constitutions in which this salutary nutriment seems to disagree. A propensity to generate bile, or too strong a disposition to acescency from a weakness of the digestive organs, both merit attention. Whey, either from cows or goats milk, appears to be more suitable in the former case; and for correcting acidity, lime water may be added to the milk. The method of adding rum or brandy to asses or cows milk, should be used with great caution: for when added beyond a certain quantity, as is often the case, they not only coagulate the milk, but heat the body; by which means the milk disagrees with the patient, and the spirit augments the disease.

In consumptive cases, Dr Simmons observes, that the patient's taste should be consulted; and says that a moderate use of animal food, where the salted and high-seasoned kinds are avoided, is not to be denied. Shell-fish, particularly oysters, are useful, as well as snails swallowed whole, or boiled in milk.

Repeated bleedings, in small quantities, are by some considered in consumptive cases as highly advantageous: and in particular circumstances they undoubtedly are so; for instance, when the constitution apparently abounds with blood; when the fluid drawn off is extremely sizy; when there is much pain in the breast; and when venesection is followed by an abatement of every symptom. In these cases, bleeding is certainly proper, and ought to be repeated so long as it seems to be attended with advantage. In very delicate constitutions, however, even where the pulse is quick, with some degree of fulness, and the blood last drawn considerably sizy, it may not prove serviceable.

It deserves to be remarked, that the inflammatory appearance of the blood is not alone a sufficient reason for bleeding; but, in determining the propriety of this evacuation, all other circumstances should be considered; such as the patient's age, strength, habit, and the state of the disease.

A remark which has been judiciously made by Dr Fothergill, ought not to be omitted in the account of this disease. It is, that young delicate females, about the age of 15 or 16, and upwards, are often subject to consumptions. When the disease has advanced considerably, the *menses*, if they have made their appearance, most generally cease. This alarms their female friends, and they call upon the physician to use his utmost endeavours for restoring the discharge; believing the cessation of it to be the immediate cause of the phthisical complaint. Induced by their solicitations, medicines have sometimes been administered, which, without obtaining this end, have tended to aggravate the distemper. This deficiency is often of no real disadvantage in those cases; and in many the evacuation would prove injurious, by diminishing the strength, which is already too much impaired. Even small bleedings at the regular periods have often done more harm than good. A sudden suppression may require bleeding; but when the evacuation fails through want of strength, and from poverty of blood, the renewal of it increases the disease.

Besides these remedies, Dr Simmons strongly recommends a frequent repetition of vomits. Many physicians have supposed, that where there is any increased determination to the lungs, vomits do mischief: but Dr Simmons is persuaded, that instead of augmenting, they diminish this determination; and that much good may be expected from a prudent use of this remedy, than which none has a more general or powerful effect on the system. If any remedy be capable of dispersing a tubercle, he believes it to be emetics. The affections of the liver, that sometimes accompany pulmonary complaints, give way to repeated emetics sooner than to any other remedy. In several cases where the cough and the matter expectorated, the flushing heats, loss of appetite, and other symptoms, threatened the most fatal event; the complaints were greatly relieved, and in others wholly removed, by the frequent use of emetics. Other suitable remedies were indeed employed at the same time; but the relief the patients generally experienced after the emetic, was a sufficient proof of its salutary operation. By this, however, he does not mean that vomits will be useful in every period of the disease, or in every patient. In general, it will be fonnd that the earlier in the disease emetics are had recourse to, the more likely they will be to do good, and the less likely to do harm. The cases in which emetics may be reckoned improper, are commonly those in which the disease is rapid in its progress; or in that stage of it when there is great debility, with profuse colliquative sweats.

In these cases, when an emetic has been administered twice a-week, and the cough is mitigated, the expectoration facilitated, and the other symptoms relieved, both the patient and the physician will be encouraged to proceed, and to repeat the vomit every second day, or even every day, for several days together, as Dr Simmons has sometimes done when the good effects of it were obvious.

The choice of emetics to be employed in these cases is by no means a matter of indifference. Carduus tea, chamomile tea, warm water, and others that act by their bulk, and by exciting nausea, relax the tone of the stomach when they are frequently repeated, and of course will be improper. More active emetics are therefore to be preferred; and here some of the preparations of antimony might naturally be thought of. But the operation of these is not confined to the stomach. They produce evacuations by stool, and a disposition to sweat; and are therefore improper in the pulmonary hectic. The mildness and excellence of ipecacuanha as an emetic, are well known; but in these cases, Dr Simmons has often employed the sulphate of copper, concerning the effects of which we meet with some groundless assertions in several medical books. Its operation is confined to the stomach; it acts almost instantaneously; and its astringency seems to obviate the relaxation that is commonly supposed to attend the frequent use of emetics. In two cases

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he experienced its good effects, after vomits of ipecacuanha had been given ineffectually. It should be administered in the morning, and in the following manner:

Let the patient first swallow about half a pint of water, and immediately afterwards sulphate of copper dissolved in a cupful of water. The dose of it must be adapted to the age and other circumstances of the patient, and may be varied from two grains to ten, fifteen, or twenty. As some persons are much more easily puked than others, it will be prudent to begin with a small dose: not that any dangerous effects will be produced by a large one, for the whole of the medicine is instantly rejected; but if the nausea be violent, and of long continuance, the patient may perhaps be discouraged from repeating it. In general, the moment the emetic has reached the stomach it is thrown up again. The patient must then swallow another half pint of water, which is likewise speedily rejected; and this is commonly sufficient to remove the nausea.

Dr Marryat, in his *New Practice of Physic*, prescribes with great freedom what he calls the *dry vomit*, from its being directed to be taken without drinking. This medicine consists of sulphate of copper and tartrite of antimony. It has the benefit also of producing instantaneous operation; but it is more apt to excite nausea than the sulphate of copper alone, and is liable to some of the objections stated to antimonial emetics.

Another remedy which Dr Simmons strongly recommends in consumptive cases, both from his own observation, and on the authority also of many other eminent practitioners, is gum-myrrh. This given by itself to the extent of a scruple or half a drachm for a dose, two or three times a-day, or, if there be much inflammatory tendency, combined with a proportion of nitre or of cream of tartar, has often been serviceable in cases which were apparently instances of incipient phthisis even of the tuberculous kind. But when the disease is far advanced, or even decidedly marked, as far as our experience goes it has rarely been productive of any benefit.

Besides the use of internal remedies in pulmonary affections, physicians have often prescribed the smoke of resinous and balsamic substances to be conveyed into the lungs. The vapour of sulphuric ether, dropt into warm water, has likewise been used in these cases. The inhaling of fixed air has also been spoken of as an useful practice. Dr Simmons has seen all these methods tried at different times; but without being able to perceive any real advantages from them in the suppurative stage of the disease, where they might be expected to be of the greatest use; and in the beginning he has often found the two first to be too stimulating. He therefore preferred the simple vapour of warm water, and has experienced its excellent effects in several instances; but when the complaint has made any considerable progress, its utility is less obvious; and when the patients have been much weakened, he has seen it bring on profuse sweats, especially when used in bed, and therefore he generally recommended it to be used in the day time. Formerly he made use of a fumigating machine, described in the Gentleman's Magazine for 1748, in which the air, inspired by the patient, is made to pass through hot water by means of a tube that communicates with the external air, and with the bottom of the vessel: but we have now a more elegant, and, on account of the valve and mouth-piece, a more useful instrument of this kind, the inhaler, invented by the ingenious Dr Mudge.

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Another remedy recommended by some as a specific in consumptions is the earth-bath. Van Swieten, in his Commentaries on Boerhaave, tells us, from the information of a person of credit, that in some parts of Spain they have a method of curing the phthisis pulmonalis by the use of this remedy; and he quotes the celebrated Solano de Luque in confirmation of this practice. Solano speaks of the *banos de tierra*, or earth-baths, as a very old and common remedy in Granada and some parts of Andalusia, in cases of hectic fever and consumptions; and relates several instances of their good effects in his own practice. The method he adopted on these occasions was as follows: He chose a spot of ground on which no plants had been sown, and there he made a hole large and deep enough to admit the patient up to the chin. The interstices of the pit were then carefully filled up with the fresh mould, so that the earth might everywhere come in contact with the patient's body. In this situation the patient was suffered to remain till he began to shiver or felt himself uneasy; and during the whole process, Solano occasionally administered food or some cordial medicine. The patient was then taken out, and, after being wrapped in a linen cloth, was placed upon a mattress, and two hours afterwards his whole body was rubbed with an ointment, composed of the leaves of the *solanum nigrum* and hog's lard. He observes, that a new pit must be made every time the operation is repeated; and advises the use of these baths only from the end of May to the end of October. Dr Fouquet, an ingenious French physician, has tried this remedy in two cases. In one, a confirmed phthisis, he was unsuccessful; but the remedy had not a fair trial. The patient, a man 30 years of age, had been for several months afflicted with cough, hectic fever, and profuse colliquative sweats. He was first put into the earth in the month of June; but soon complained of an uneasy oppression at his stomach, and was removed at the end of seven minutes. The second time he was able to remain in it half an hour, and when taken out was treated in the way prescribed by Solano. In this manner the baths were repeated five times, and the patient was evidently relieved; but having conceived a dislike to the process, he refused to submit to any further trials, and died some months afterwards. In the second case he was more fortunate: the patient, a girl 11 years of age, had been for three months troubled with a cough brought on by the measles, which was at length attended with a purulent expectoration, hectic fever, and night sweats. She began the use of the earth-bath in August, and repeated it eight times in the space of 20 days. At the end of that time the fever and disposition to sweat had entirely ceased, and by the use of the common remedies, the patient was perfectly restored. A physician at Warsaw has likewise prescribed the earth-bath with good success in cases of hectic fever. The Spaniards confine it entirely to such cases; but in some other parts of the world we find a similar method employed as a remedy for other diseases, and particularly for the sea-scurvy. Dr Priestley observes, that the Indians, he has been told, have a

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a custom of burying their patients labouring under putrid diseases up to the chin in fresh mould, which is also known to take off the fœtor from flesh meat beginning to putrefy. The rancidity of a ham, for example, may be corrected by burying it for a few hours in the earth. The efficacy of this remedy in the sea scurvy has, it is said, frequently been experienced by the crews of our East India ships.

Solano, who is fond of philosophizing in his writings, is of opinion, that the earth applied in this way absorbs the morbid taint from the system; but does it not seem more probable, that the effluvia of the earth, by being absorbed and carried into the circulation, correct the morbid state of the fluids, and thus are equally useful in the sea scurvy and in the pulmonary hectic? That the earth when moistened does emit a grateful odour is a fact generally known; and Baglivi long ago gave his testimony in favour of the grateful effects of the effluvia of fresh earth. He ascribes these good effects to the nitre it contains.

The earth-bath, both in consumptive cases and likewise in a variety of other affections, has of late been extensively employed in Britain by a celebrated empiric. But, as far as we can learn, in most cases it produced to the patient a very distressing sensation of cold; in some, it seemed to be productive of bad effects, probably in consequence of this cold; and we have not heard of any consumptive cases in which good effects were decidedly obtained from it.

With regard to the drains, such as blisters, issues, and setons, which are so frequently recommended in pulmonary complaints, there is less danger of abuse from them than from the practice of venesection. The discharge they excite is not calculated to weaken the patient much; and the relief they have so often been found to afford, is a sufficient reason for giving them a trial. Blisters, as is well known, act in a twofold manner; by obviating spasm, and producing revulsion: Issues and setons act chiefly in the latter of these two ways; and in this respect their effects, though less sudden and less powerful at first, are more durable from the continuance of the discharge they occasion. It is perhaps hardly necessary to remark, that, if much service is to be expected from either of these remedies, they should be applied early in the disease. The ingenious Dr Mudge, who experienced the good effects of a large scapulary issue on his own person, very properly observes, that the discharge in these cases ought to be considerable enough to be felt. But it is seldom possible for us to prevail on the delicate persons, who are most frequently the victims of this disease, to submit to the application of a caustic between the shoulders. The discharge produced by a seton is by no means inconsiderable; and as in these cases there is generally some part of the breast that is more painful or more affected by a deep inspiration than the rest, a seton in the side, as near as can be to the seat of the pain, will be an useful auxiliary. Dr Simmons has seen it evidently of great use in several cases.

Genus XXXVIII. HÆMORRHOIS.

Hæmorrhoids, or *Piles*.

Hæmorrhois, *Sauv.* gen. 217. *Lin.* 192. *Sag.* gen. 182.
Hæmorrhoidalis fluxus, *Hoffm.* 219.
Hæmorrhoides, *Junck.* 11. et 12.
Leucorrhois, *Vog.* 112.

Sp. I. *External Piles.* 241

Var. A. *Bloody Piles.*

Hæmorrhois moderata, *Sauv.* sp. 1.
Hæmorrhoides ordinatæ, *Junck.* 11.
Hæmorrhoides nimiæ, *Junck.* 11.
Hæmorrhois immodica, *Sauv.* sp. 2.
Hæmorrhoides excedentes, *Alberti* de hæmorrhoid. p. 179.
Hæmorrhois polyposa, *Sauv.* sp. 3.

Var. B. *Mucous Piles.*

Hæmorrhoides decoloratæ, albæ, et mucidæ, *Junck.* 13. *Alberti*, p. 248.

Sp. II. The *Piles* from a *Procidentia Ani.* 242

Hæmorrhois ab exania, *Sauv.* sp. 4.

Sp. III. The *Running Piles.* 243

Sp. IV. The *Blind Piles.* 244

Hæmorrhoides cœcæ, *Junck.* 12. *Alberti*, p. 274.

Description. The discharge of blood from small tumors on the verge of the anus constitutes what is called the *hæmorrhoids* or *piles*. They are distinguished into the *external* and *internal*, according to the situation of the tumors, either without or within the anus. Sometimes, however, these tumors appear without discharging any blood; and in this case they are called the *hæmorrhoides cœcæ*, or *blind piles*. Sometimes the disease appears without the verge of the anus in distinct separate tumors; but frequently only one tumid ring appears, seeming as it were the anus pushed without the body. Sometimes these tumors appear without any previous disorder of the body: but more frequently, before the blood begins to flow, and sometimes even before the tumors are formed, various affections are perceived in different parts of the body; as headach, vertigo, stupor, difficulty of breathing, sickness, colic pains, pain of the back and loins, and frequently a considerable degree of pyrexia; while along with these symptoms there is a sense of fulness, heat, itching, and pain, in and about the anus. Sometimes the disease is preceded by a serous discharge from the anus; and sometimes this serous discharge, accompanied with swelling, seems to come in place of the discharge of blood, and to relieve the above-mentioned disorders of the system. This serous discharge hath therefore been named the *hæmorrhois alba*.

In this disease the quantity of blood discharged is different upon different occasions. Sometimes it flows only when the person goes to stool, and commonly follows the discharge of fæces. In other cases it flows without any discharge of fæces; and then generally in consequence of the disorders above mentioned, when it is also commonly in larger quantity. This is often very considerable; and, by the repetition, so great, that we could hardly suppose the body to bear it but with the

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the hazard of life. Indeed, though rarely, it has been so great as to prove suddenly fatal. These considerable discharges occur especially to persons who have been frequently liable to the disease. They often induce great debility, and frequently a leucophlegmatia or dropsy which proves fatal. Sometimes the tumors and discharges of blood in this disease recur exactly at stated periods. In the decline of life it frequently happens that the hæmorrhoidal flux, formerly frequent, ceases to flow; and in that case it generally happens that the persons are affected with apoplexy or palsy. Sometimes hæmorrhoidal tumors are affected with inflammation, which ends in suppuration, and gives occasion to the formation of fistulous ulcers in those parts.

The hæmorrhoidal tumors have often been considered as varices or dilatations of the veins; and in some cases varicous dilatations have appeared on dissection. These, however, do not appear in the greater part of cases; and Dr Cullen is of opinion that they are usually formed by an effusion of blood into the cellular texture of the intestine near to its extremity. When recently formed, they contain fluid blood; but after they remain for some time they are usually of a firmer consistence, in consequence of the blood being coagulated.

Causes, &c. It would seem probable, that the hæmorrhoidal tumors are produced by some interruption of the free return of the blood from the rectum, by which a rupture of the extremities of the veins is occasioned. But considering that the hæmorrhage occurring here is often preceded by pain, inflammation, and a febrile state, and with many other symptoms which show a connection of the topical affection with the state of the whole system, it is probable that the interruption of the blood in the veins produces a considerable resistance to the motion of the blood through the arteries, and consequently that the discharge of blood is commonly from the latter. Some have thought, that a difference of the hæmorrhois, and of its effects upon the system, might arise from the difference of the hæmorrhoidal vessels from whence the blood issued. But Dr Cullen is of opinion, that we can scarce ever distinguish the vessels from which the blood flows, and that the frequent inosculations of both arteries and veins belonging to the lower extremity of the rectum, will render the effects of the hæmorrhage much the same, from whatever source it proceeds.

With regard to the hæmorrhoids, however, he is of opinion, that they are for the most part, merely a topical affection. They take place before the period of life at which a venous plethora happens. They happen to females, in whom a venous plethora determined to the hæmorrhoidal vessels cannot be supposed to occur; and they happen to both sexes, and to persons of all ages, from causes which do not affect the system, and are manifestly suited to produce a topical affection only.

These causes are, in the first place, the frequent voiding of hard and bulky fæces, which, by their long stagnation in the rectum, and especially when voided, must necessarily press upon the veins of that part, and interrupt the course of the blood in them. For this reason the disease so frequently happens to those who are habitually costive. From the same causes, the disease happens frequently to those who are subject to a prolapsus ani. In voiding the fæces, it almost always happens that the internal coat of the rectum is more or less protruded; and, during this protrusion, it sometimes happens that the sphincter ani is contracted: in consequence of this, a strong constriction is made, which preventing the protruded gut from being replaced, and at the same time preventing the return of the blood from it, occasions a considerable swelling, and the formation of a tumid ring round the anus.

Upon the sphincter's being a little relaxed, as it is immediately after its strong contraction, the portion of the gut which had fallen out is commonly taken into the body again; but by the frequent repetition of the accident, the size and fulness of the ring formed by the prolapsed intestine is much increased. It is therefore more slowly and difficultly replaced; and in this consists the chief uneasiness of hæmorrhoidal persons. As the internal edge of this ring is necessarily divided by clefts, the whole often puts on the appearance of a number of distinct swellings; and it also frequently happens, that some portions of it are more considerably swelled, become more protuberant, and form those small tumors more strictly called *hæmorrhoids* or *piles*.

From considering that the pressure of the fæces, and other causes interrupting the return of venous blood from the lower extremity of the rectum, may operate a good deal higher up than that extremity, we may understand how tumors may be formed within the anus; and probably it also happens, that some of the tumors formed without the anus may continue when taken within the body, and even be increased by the causes just mentioned. Thus may the production of internal piles be explained, which, on account of their situation and bulk, are not protruded on the person's going to stool, and are therefore more painful.

The production of piles is particularly illustrated by this, that pregnant women are frequently affected with the disease. This is to be accounted for, partly from the pressure of the uterus upon the rectum, and partly from the costive habit to which pregnant women are liable. Dr Cullen has known many instances of piles happening for the first time during the state of pregnancy; and there are few women who have born children, that are afterwards entirely free from piles. —Purgatives also, especially those of the more acrid kind, and particularly aloetics, are apt to produce the piles when frequently used; and as they stimulate particularly the larger intestines, they may be justly reckoned among the exciting causes of this disease.

Prognosis. Though the hæmorrhoids are commonly, as we have said, to be esteemed a topical disease, they may, by frequent repetition, become habitual and connected with the state of the whole system; and this will more readily happen in persons who have been once affected with the disease, if they be frequently exposed to the renewal of the causes which occasioned it. It happens also to persons much exposed to a congestion in the hæmorrhoidal vessels, in consequence of their being often in an erect position of the body, and in an exercise which pushes the blood into the depending vessels, while at the same time the effects of these circumstances are much favoured by the abundance and

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and laxity of the cellular texture about the anus. It is to be particularly observed, that when an hæmorrhoidal affection has either been originally or has become a disease of the system, it then acquires a particular connection with the stomach; so that certain affections of the stomach excite the hæmorrhoidal disease, and certain states of this disease excite the disorders of the stomach.

It has been an almost universally received opinion, that the hæmorrhoidal flux is a salutary evacuation, which prevents many diseases which would otherwise have happened; and that it even contributes to give long life: and as this opinion has been strenuously adopted by Dr Stahl, it has had a very considerable influence on the practice of physic in Germany. But Dr Cullen maintains that we can never expect to reap much benefit from this flux, which at first is purely topical; and, granting that it should become habitual, it is never, he thinks, proper to be encouraged. It is a disagreeable disease; ready to go to excess, and thereby to prove hurtful, and sometimes even fatal: at best it is liable to accidents, and thus to unhappy consequences. He is therefore of opinion, that even the first approaches of the disease are to be guarded against; and that, though it should have proceeded for some time, it ought always to be moderated, and the necessity of it superseded.

Cure. The general intention of cure in cases of hæmorrhois are much varied, according to the circumstances of the affection at the time. When hæmorrhois exists in the state of tumor, the principal objects are to counteract inflammation, and to promote a discharge of blood from the part. When it is in the state of evacuation, the chief intentions of cure are, to diminish the impetus of blood at the part affected, and to increase the resistance to the passage of blood through the ruptured vessels. And finally, when the disease exists in the state of suppression, the aims of the practitioner must chiefly be, to obviate the particular affections which are induced in consequence of the suppression; to restore the discharge, as a means of mitigating these and preventing others; or, when the discharge cannot with propriety or advantage be restored, to compensate the want of it by vicarious evacuations.

With these various intentions in different cases, a variety of different remedies may be employed with advantage.

When any evident cause for this disease is perceived, we ought immediately to attempt a removal of that cause. One of the most frequent remote causes is an habitual costiveness; which must be obviated by a proper diet, such as the person's own experience will best direct; or if the management of diet be not effectual, the belly must be kept open by medicines, which may prove gently laxative, without irritating the rectum. In most cases it will be of advantage to acquire a habit with regard to the time of discharge, and to observe it exactly. Another cause of the hæmorrhois to be especially attended to is the prolapsus ani, which is apt to happen on a person's having a stool. If this shall occur to any considerable degree, and be not at the same time easily and immediately replaced, it most certainly produces piles, or increases them when otherwise produced. Persons therefore who are liable to this prolapsus, should, after having been at stool, take great pains to have the intestine immediately replaced, by lying down in a horizontal posture, and pressing gently upon the anus, till the reduction shall be completely obtained. When this prolapsus is occasioned only by the voiding of hard and bulky fæces, it is to be removed by obviating the costiveness which occasions it. But in some persons it is owing to a laxity of the rectum; and in those it is often most considerable on occasion of a loose stool. In these cases, it is to treated by astringents, and proper artifices are to be employed to keep the gut in its place.

When the disease has frequently recurred from neglect, and is thus in some measure established, the methods above mentioned are no less proper; but in this case some other measures must also be used. It is especially proper to guard against a plethoric state of the body; and therefore to avoid a sedentary life, full diet, and intemperance in the use of strong liquor, which in all cases of hæmorrhage is of the most pernicious consequence.

Exercise of all kinds is of great service in obviating and removing a plethoric state of the body; but upon occasion of the hæmorrhoidal flux, when this is immediately to come on, both walking and riding, as increasing the determination of the blood into the hæmorrhoidal vessels, are to be avoided. At other times, when no such determination is already formed, these modes of exercise may be very properly employed.

Another method of removing plethora is by cold bathing; but this must be employed with caution. When the hæmorrhoidal flux is approaching, it may be dangerous to divert it; but during the intervals of the disease, cold bathing may be employed with safety and advantage; and in those who are liable to a prolapsus ani, the frequent washing of the anus with cold water may be useful.

Besides general antiphlogistic regimen, in some cases where the inflammation runs high, recourse may be had with great advantage both to general blood-letting and to leeches applied at the anus. Relief is also often obtained from the external application of emollients, either alone or combined with different articles of the sedative kind, as acetite of lead or opium, by which it is well known that pain in general, particularly when depending on increased sensibility, or augmented action of the vessels, is powerfully allayed.

When the flux has actually come on, we are to moderate it as much as possible, by causing the patient lie in a horizontal posture on a hard bed; by avoiding exercise in an erect posture, using a cool diet, and avoiding external heat. But with respect to the further cure of this disease, we must observe, that there are only two cases in which it is common for hæmorrhoidal persons to call for medical assistance. The one is, when the affection is accompanied with much pain; and the other, when the piles are accompanied with excessive bleeding. In the first case, we must consider whether the piles be external or internal. The pain of the external piles happens especially when a considerable protrusion of the rectum has taken place; and while it remains unreduced, it is strangled by the constriction of the sphincter; and at the same time no bleeding happens to take off the swelling of the pro-

Hæmorrhagiæ. truded portion of the intestine; and sometimes an inflammation supervenes, which greatly aggravates the pain. In this case, emollient fomentations and poultices are sometimes of service, but the application of leeches is generally to be preferred.

In case of excessive bleeding, we are on all occasions to endeavour to moderate the flux, even where the disease has occurred as a critical discharge; for if the primary disease shall be entirely and radically cured, the preventing any return of the hæmorrhois seems perfectly safe and proper. It is only when the disease arises from a plethoric habit, and from a stagnation of blood in the hypochondriac region, or when, though originally topical, it has by frequent repetition become habitual, and has thereby acquired a connection with the system, that any doubt can arise about curing it entirely. In any of these cases, however, Dr Cullen is of opinion, that it will be proper to moderate the bleeding, lest, by its continuance or repetition, the plethoric state of the body, and the particular determination of the blood into the hæmorrhoidal vessels, be increased, and the return of the disease be too much favoured. Dr Stahl is of opinion, that the hæmorrhoidal flux is never to be accounted excessive, excepting when it occasions great debility or leucophlegmatia: but Dr Cullen thinks, that the smallest approach towards producing either of these effects should be considered as an excess which ought to be prevented from going farther; and even in the cases of congestion and plethora, if the plethoric habit and tendency can be obviated and removed, the hæmorrhoidal flux may then with safety be entirely suppressed. In all cases therefore of excessive bleeding, or any approach to it, astringents both internal and external may be safely and properly applied; not indeed to induce an immediate and total suppression; but to moderate the hæmorrhage, and by degrees to suppress it altogether; while at the same time measures are to be taken for the removing the necessity of its recurrence.

Genus XXXIX. MENORRHAGIA.

245 *Immoderate Flow of the Menses.*

Menorrhagia, *Sauv.* 244. *Lin.* 202. *Vog.* 96.
Menorrhagia, *Sag.* gen. 179.
Uteri hæmorrhagia, *Hoffm.* II. 224.
Hæmorrhagia uterina, *Junck.* 14.
Leucorrhœa, *Sauv.* gen. 267. *Lin.* 201. *Vog.* 119. *Sag.* gen. 202.
Cachexia uterina, sive fluor albus, *Hoffm.* III. 348.
Fluor albus, *Junck.* 133.
Abortus, *Sauv.* gen. 245. *Lin.* 204. *Sag.* gen. 180. *Junck.* 92.
Abortio, *Vog.* 97.
Fluor uterini sanguinis, *Boerh.* 1303.
Convulsio uteri, sive abortus, *Hoffm.* III. 176.

246 Sp. I. The *Immoderate Flow* of the *Menses*, properly so called.

Menorrhagia rubra, *Cul.*
Menorrhagia immodica, *Sauv.* sp. 3.
Menorrhagia stillatitia, *Sauv.* sp. 2.

Description. The quantity of the menstrual flux is different in different women, and likewise in the same woman at different times. An unusual quantity therefore is not always to be considered as morbid: but when a large flow of the menses has been preceded by headach, giddiness, or dyspnœa; has been ushered in by a cold stage; and is attended with much pain of the back and loins, with a frequent pulse, heat, and thirst, it may then be considered as preternaturally morbid. On the other hand, when the face becomes pale, the pulse weak, an unusual debility is felt in exercise, and the breathing is hurried by little labour; when the back becomes pained from any continuance in an erect posture, when the extremities become frequently cold, and when at night the feet appear affected with œdematous swelling; from all these symptoms we may conclude, that the flow of the menses has been immoderate, and has already induced a dangerous state of debility. The debility, induced in this case, often appears also by affections of the stomach, an anorexia, and other symptoms of dyspepsia; by a palpitation of the heart, and frequent faintings; by a weakness of mind, liable to strong emotions from slight causes, especially those presented by surprise. A large flow of the menses attended with barrenness in married women, may generally be considered as preternatural and morbid. Generally, also, that flow of the menses may be considered as immoderate, which is preceded and followed by a leucorrhœa.

Causes, &c. The proximate cause of the menorrhagia is either the effort of the uterine vessels preternaturally increased, or a preternatural laxity of the extremities of the uterine arteries.—The remote causes may be, 1. Those which increase the plethoric state of the uterine vessels; as a full and nourishing diet, much strong liquor, and frequent intoxications. 2. Those which determine the blood more copiously and forcibly into the uterine vessels; as violent strainings of the whole body; violent shocks from falls; strokes or contusions on the lower belly; violent exercise, particularly in dancing; and violent passions of the mind. 3. Those which particularly irritate the vessels of the uterus; as excess in venery; the exercise of venery in the time of menstruation; a costive habit, giving occasion to violent straining at stool; and cold applied to the feet. 4. Those which have forcibly overstrained the extremities of the uterine vessels; as frequent abortions, frequent childbearing without nursing, and difficult or tedious labours. Or, lastly, Those which induce a general laxity; as living much in warm chambers, and drinking much of warm enervating liquors, such as tea, coffee, &c.

Cure. The treatment and cure of the menorrhagia, must be different according to the different causes of the disease. The practices employed, however, are chiefly used with one of two intentions; either with the view of restraining the discharge when present, or of preventing the return of an excessive discharge at the succeeding period. The first is chiefly to be accomplished by employing such practices as diminish the force occasioning the discharge of blood, or as augment the resistance to its passage through the vessels by which it is to be discharged. The last is in some degree to be obtained by avoiding causes which either increase the general impetus of the blood, or the impetus at the uterus in particular; but principally

Menorrhagiæ.

pally by giving additional vigour to the uterine vessels.

In all cases, the first attention ought to be given to avoiding the remote causes, whenever they can be done; and by such attention the disease may be often entirely cured. When the remote causes cannot be avoided, or when the avoiding them has been neglected, and a copious menstruation has come on, it should be moderated as much as possible, by abstaining from all exercise at the coming on or during the continuance of the menstruation; by avoiding even an erect posture as much as possible; by shunning external heat, and of course warm chambers and soft beds; by using a light and cool diet; by taking cold drink, at least as far as former habits will allow; by avoiding venery; by obviating costiveness, or removing it by laxatives which give little stimulus. The sex are commonly negligent, either in avoiding the remote causes, or in moderating the first beginnings of this disease. It is by such neglect that it so frequently becomes violent and of difficult cure; and the frequent repetition of a copious menstruation may be considered as a cause of great laxity in the extreme vessels of the uterus.

When the coming on of the menstruation has been preceded by some disorder in other parts of the body, and is accompanied with pains of the back, somewhat like parturient pains, with febrile symptoms, and when at the same time the flow seems to be copious, a bleeding at the arm may be proper, but is not often necessary; and it will in most cases be sufficient to employ, with great attention and diligence, those means already mentioned for moderating the discharge.

When the immoderate flow of the menses shall seem to be owing to a laxity of the vessels of the uterus, as may be concluded from the general debility and laxity of the person's habit; from the remote causes that have occasioned the disease; from the absence of the symptoms which denote increased action in the vessels of the uterus; from the frequent recurrence of the disease; and particularly from this, that the female in the intervals of menstruation is liable to a leucorrhœa: in such a case, the disease is to be treated, not only by employing all the means above mentioned for moderating the hæmorrhage, but also by avoiding all irritation, every irritation having a greater effect in proportion as the vessels are more lax and yielding. If, in such a case of laxity, it shall appear that some degree of irritation occurs, opiates may be employed to moderate the discharge; but in using these much caution is requisite. If, notwithstanding these measures having been taken, the discharge shall prove very large, astringents both external and internal may be employed. In such cases, Dr Cullen asks, May small doses of emetics be of service?

When the menorrhagia depends on the laxity of the uterine vessels, it will be proper, in the intervals of menstruation, to employ tonic remedies; as cold bathing and chalybeates. The exercises of gestation also may be very useful, both for strengthening the whole system, and for taking off the determination of the blood to the internal parts.

These remedies may be employed in all cases of menorrhagia, from whatever cause it may have proceeded, if it shall have already induced a considerable degree of debility in the body.

Leucorrhœa.

Sp. II. *Abortion.* 247

Menorrhagia abortus, *Cul.*
Menorrhagia gravidarum, *Sauv.* sp. 6.
Abortus effluxio, *Sauv.* sp. 1.
a, Abortus subtrimestris.
b, Abortus subsemestris.
c, Abortus octimestris.
Abortus ab uteri laxitate, *Sauv.* sp. 2.

Sp. III. *Immoderate Flux* of the *Lochia.* 248

Menorrhagia lochialis, *Sauv.* sp. 8. *Cul.*

For the description, treatment, and cure, of these two last diseases, see Midwifery.

Sp. IV. *Immoderate Flow* of the *Menses* from some local disorder. 249

Menorrhagia vitiorum, *Cul.*
Menorrhagia ex hysteroptosi, *Sauv.* sp. 5.
Menorrhagia ulcerosa, *Sauv.* sp. 9.

Sp. V. The *Leucorrhœa, Fluor Albus,* or *Whites.* 250

Menorrhagia alba, *Cul.*
Leucorrhœa, *Sauv.* gen. 267.
Menorrhagia decolor, *Sauv.* sp. 7.
Leucorrhœa Americana, *Sauv.* sp. 5.
Leucorrhœa Indica, *Sauv.* sp. 6.
Leucorrhœa Nabothi, *Sauv.* sp. 9.
Leucorrhœa gravidarum, *Sauv.* sp. 8.

Description. The *fluor albus,* female weakness, or *whites,* as it is commonly called, is a disease of the womb and its contiguous parts; from which a pale-coloured, greenish, or yellow fluid is discharged, attended with loss of strength, pain in the loins, bad digestion, and a wan sickly aspect.

Causes, &c. The quantity, colour, and consistence of the discharge chiefly depend upon the time of its duration, the patient's habit of body, and the nature of the cause by which it was produced. Taking cold, strong liquor, immoderate heat and moisture, or violent exercise, are all observed to produce a bad effect, as to its quantity and quality.

Weakly women of lax solids, who have had many children, and long laboured under ill health, are of all the most subject to this disagreeable disease; from which they unfortunately suffer more severe penance than others, as the nicest sensations are often connected with such a delicacy of bodily frame as subjects them to it.

In Holland it is very frequent, and in a manner peculiar to the place, from the dampness of its situation; the surrounding air being so overcharged with moisture as to relax the body, stop perspiration, and throw it upon the bowels or womb; producing in the first a diarrhœa or flux, in the last the *fluor albus* or female weakness.

The discharge often proceeds from the vessels subservient to menstruation; because, in delicate habits, where those vessels are weak, and consequently remain too long

long uncontracted, the *fluor albus* sometimes immediately follows the menses, and goes off by degrees as they gradually close. It also comes from the mucous glands of the womb, as is particularly evident in very young females of eight and ten years old; in whom, though very rarely, it has been observed, and where it must then necessarily have escaped from those parts, as the uterine vessels are not sufficiently enlarged for its passage at so early a period.

Sometimes, as in women with child, it proceeds from the passage to the womb, and not from the womb itself; which, during pregnancy, is closely sealed up, so that nothing can pass from thence till the time of labour. The application of those instruments called *pessaries*, from the pain and irritation they occasion, is also apt to bring on this discharge. Hence we may conclude, that this disease may happen although the blood be in a pure state. Here the fault seems to be placed in the vessels at the part, by which the fluids are vitiated and changed from their natural qualities.

The *fluor albus* has been supposed to supply the want of the menses; because where the first prevails, the last is generally either irregular or totally wanting: but it might more properly be said, that the presence of the *fluor albus*, which is a preternatural evacuation, occasions the absence of that which is natural; as is evident from the return of the menses after the *fluor albus* has been cured. Indeed, when this discharge appears about the age of 13 or 14, and returns once a month, with symptoms like those of the menses, then it may be deemed strictly natural, and therefore ought not to be stopped.

Prognosis. The *fluor albus* may be distinguished into two kinds. The first arises from a simple weakness, or the relaxation of the solids; which may either be *general*, where the whole bodily system is enervated and unstrung; or *partial*, where the womb only is thus affected, in consequence of hard labour, frequent miscarriages, a suppression or immoderate quantity of the menses, or a sprain of the back or loins.

In the first case, the discharge being generally mild, may be safely taken away. In the second, it may proceed from a vitiated or impure blood, where the body, from thence, is loaded with gross humours, which nature for her own security and relief thus endeavours to carry off. In such cases, the discharge is often of a reddish colour, like that from old ulcerous sores; being sometimes so sharp as to excoriate the contiguous parts, and occasion a smarting and heat of urine.

A deep-seated, darting pain, with a forcing down, attending such a discharge is a very dangerous and alarming sign, and indicates an ulceration or cancerous state of the womb. This malignant state of the disease, if of long continuance, is extremely difficult to cure; and disposes the patient to barrenness, a bearing down, dropsy, or consumption.

Cure, &c. The causes of those two kinds of this disease being different, so they will require a very different method of cure. For this purpose, in the first case, nothing will be more proper than nourishing simple food; such as veal broths, jellies, fresh eggs, and milk diet. The acid fruits will also be proper; and the patient may take a restorative, strengthening infusion, which will give firmness to the body, and assist the weakened fibres of the womb in returning to their natural state.

The same method may be used with success, where the *fluor albus* follows the menses, as already observed.

The Tunbridge or Spa waters may be drank at the same time; and, if necessary, an infusion of green tea, or pure smith's forge water, may be used with a womb-syringe as an injection twice a-day. Should the disease prove uncommonly obstinate, the patient may go into the cold bath every second day; and also drink lime-water with milk, which will expedite the cure, and prevent a relapse. Volatile liniment, and afterwards a strengthening plaster, may be applied to the small of the back.

By way of caution, the female should abstain from the immoderate use of tea; and be removed into a dry clear air; or if she be obliged to remain in one less proper, she may apply the flesh-brush, and wear a flannel shift next her skin, impregnated with the fumes of burning frankincense or any of the grateful aromatic gums. Cold spring water pumped on the loins, or a blistering plaster applied to the bottom of the spine or back, are both very powerful in their effects, and have sometimes succeeded after other remedies had been tried in vain.

In the second species of the disease, where the discharge is sharp and of long standing, it would be extremely dangerous to suppress it suddenly, either by astringents internally taken, or applied as injections, until the system be restored to a more sound and vigorous condition.

A purging potion may be taken twice a-week, and in the intervals an alterative pill night and morning. After this course has been continued a fortnight or three weeks, she may begin with the strengthening bitter infusion, or some other tonic, in the quantity of a tea-cupful twice a-day, or to a greater extent if the stomach will allow.

The same sort of food and regimen will here be proper as in the first kind of the disease. The patient should abstain from malt liquors, and drink rice-water, in each pint of which half an ounce of gum-arabic has been dissolved; or if she be weak, and of a cold bloated habit of body, a little French brandy may be added occasionally.

When she begins to take the bitter infusion, it will be proper to use the Tunbridge or Pyrmont water for common drink; but if those cannot conveniently be had, the *alkaline aërated water*, impregnated with iron, will make an excellent substitute. If it should render her costive, and occasion headach, she may desist, and drink a solution of crystals of tartar, or a little senna tea sweetened with manna, till those complaints be removed.

In short, as this is a malady of the most disagreeable kind, which by long continuance or neglect becomes difficult of cure, and often produces an *ulceration of the womb*, *bearing down*, *barrenness*, a *dropsy*, or *consumption*; it were to be wished that women, on such occasions, would be more attentive to their own safety, by using all possible means, in due time, to prevent those disorders.

Dr Leake says he has attended more patients labouring under the *fluor albus* in the autumn than at any other season

season of the year, especially when the weather was uncommonly moist and cold: most of them were cured by change of diet, an increased perspiration, and the proper use of cinchona with aromatics. He observed, that several about this time who escaped the disorder, were visited with bad colds, a defluxion on the throat, or a diarrhœa, which were removed by a similar treatment.

Among other remedies which have been recommended in leucorrhœa, recourse has lately been had to the internal use of cantharides. This remedy for leucorrhœa has, in particular, been highly extolled in a late publication on the powers of cantharides, when used internally, written by Mr John Roberton, surgeon in Edinburgh. The analogy between gleet and leucorrhœa, Mr Roberton tells us, suggested to him, that the cantharides, which he had employed with such good effects in gleet, might also be used in leucorrhœa. The event, he affirms, fully answered his expectations, and he has employed the remedy with very great success. The cantharides were used under the form of tincture: the *tinctura melöes vesicatorii* of the Edinburgh Pharmacopœia. This medicine he employed in much larger doses than is commonly prescribed. Thus a mixture containing an ounce of the tincture of cantharides, diffused in six ounces of water, was taken to the extent of half an ounce, four times a day; nay, in some cases, the tincture was exhibited to the extent of half an ounce in a day, without any inconvenience, and with the best effects. As examples of the power of this remedy, Mr Roberton has given a detail of six cases, selected from a number which have been under his care. In three cases, as being the most inveterate, the effects of the cantharides were most evident. And we shall only observe, that if this remedy be found by other practitioners to be equally successful in the cure of leucorrhœa, it will be a very valuable acquisition in the practice of medicine, especially if it shall be found by others, as well as by Mr Roberton, that not only the general symptoms of leucorrhœa are removed, but that the tone and functions of the uterine system are completely restored by the use of cantharides.

As women are sometimes connected with those who do not conscientiously regard their safety, it is a circumstance of the utmost consequence *to distinguish a fresh venereal infection from the fluor albus or whites*: for if the first be mistaken for the last, and be either neglected or improperly treated, the worst consequences may arise.

The following signs will best inform the patient whether there be occasion for her doubts or not.

A fresh infection, called *gonorrhœa*, is malignant and inflammatory; the *fluor albus* most commonly arises from relaxation and bodily weakness: and therefore the remedies proper in the first disorder would render the last more violent, by locking up and confining the infectious matter.

In the gonorrhœa, the discharge chiefly proceeds from the parts contiguous to the urinary passage, and continues whilst the menses flow; but in the *fluor albus* it is supplied from the cavity of the womb and its passage, and then the menses are seldom regular.

In the gonorrhœa, an itching, inflammation, and heat of urine, are the forerunners of the discharge; the orifice of the urinary passage is prominent and painful, and the patient is affected with a frequent irritation to make water. In the *fluor albus*, pains in the loins, and loss of strength, attend the discharge; and if any inflammation or heat of urine follow, they happen in a less degree, and only after a long continuance of the discharge, which, becoming sharp and acrimonious, excoriates the surrounding parts.

In the gonorrhœa, the discharge suddenly appears without any evident cause; but in the *fluor albus*, it comes on more slowly, and is often produced by irregularities of the menses, frequent abortion, sprains, or long-continued illness.

In the gonorrhœa, the discharge is greenish or yellow, less in quantity, *and not attended with the same symptoms of weakness*. In the *fluor albus*, although sometimes of the same colour, especially in bad habits of body, and after long continuance, it is usually more offensive and redundant in quantity.

All the other kinds of hæmorrhage enumerated by medical writers, are by Dr Cullen reckoned to be symptomatic.

Stomacace, *Sauv.* gen. 241. *Lin.* 175. *Vog.* 85. *Sag.* gen. 177.

Species: Scorbutica, Purulenta, &c.

Hæmatemesis, *Sauv.* gen. 242. *Lin.* 184. *Vog.* 89. *Sag.* gen. 177.

Species: Plethorica, Catamenialis, Scorbutica, &c.

Hæmaturia, *Sauv.* gen. 233. *Lin.* 198. *Vog.* 92. *Sag.* gen. 178.

Species: Purulenta, Calculosa, Hæmorrhoidalis, &c.

Order V. PROFLUVIA.

Genus XL. CATARRHUS. 251

The *Catarrh*.

Catarrhus, *Sauv.* gen. 186. *Vog.* 98. *Sag.* gen. 145.
Coryza, *Lin.* 174. *Vog.* 100. *Sag.* gen. 196.
Rheuma, *Sauv.* gen. 142.
Tussis, *Sauv.* gen. 142. *Lin.* 155. *Vog.* 205. *Sag.* gen. 245, 255. *Junck.* 30.
Tussis catarrhalis et rheumatica, *Hoffm.* III. 109.

Sp. I. *Catarrh* from Cold. 252

Catarrhus à frigore, *Cul.*
Catarrhus benignus, *Sauv.* sp. 1.
Catarrhus pectoreus, *Sauv.* sp. 6.
Coryza catarrhalis, *Sauv.* sp. 1.
Coryza phlegmatorrhagia, *Sauv.* sp. 2. *Salmuth.* Obs. cent. 1, 37. *Junck.* 28. *Morgagn.* de sed. xiv. 21.
Coryza febricosa, *Sauv.* sp. 6.
Tussis catarrhalis, *Sauv.* sp. 1. *N. Rosen.* Diss. apud *Haller*, Disput. Pract. tom. ii.
Rheuma catarrhale, *Sauv.* sp. 1.
Amphimerina catarrhalis, *Sauv.* sp. 2.
Amphimerina tussiculosa, *Sauv.* sp. 13.
Cephalalgia catarrhalis, *Sauv.* sp. 10.

Sp. II.

Profluvia. 253

Sp. II. *Catarrh* from CONTAGION.

Catarrhus à contagio, *Cul.*
Catarrhus epidemicus, *Sauv.* sp. 3.
Rheuma epidemicum, *Sauv.* sp. 2.
Synocha catarrhalis, *Sauv.* sp. 5.

There are several symptomatic species: as, Catarrhus Rubeolosus; Tussis Variolosa, Verminosa, Calculosa, Phthisica, Hysterica, à dentitione, Gravidarum, Metallicolarum, &c.

Description. The catarrh is an increased excretion of mucus from the mucous membrane of the nose, fauces and bronchiæ, attended with pyrexia.

Practical writers and nosologists have distinguished the disease by different appellations, according as it happens to affect different parts of the mucous membrane, one part more or less than the other: but Dr Cullen is of opinion that the disease in those different parts is always of the same nature, and proceeds from the same cause in the one as in the other. Very commonly indeed, those different parts are affected at the same time; and therefore there is little room for the distinction mentioned. The disease has been frequently treated of under the title of *tussis* or *cough;* and a cough, indeed, always attends the chief form of catarrh, that is, the increased excretion from the bronchiæ; but as it is so often also a symptom of many other affections, which are very different from one another, it is improperly used as a generic title.

The disease generally begins with some difficulty of breathing through the nose, and with a sense of some fulness stopping up that passage. This again is often attended with some dull pain and a sense of weight in the forehead, as well as a stiffness in the motion of the eyes. These feelings, sometimes at their very first beginning, and always soon after, are attended with the distillation of a thin fluid from the nose, and sometimes from the eyes; and these fluids are often found to be somewhat acrid, both by their taste and by their fretting the parts over which they pass. These symptoms constitute the coryza and gravedo of authors, and are commonly attended with a sense of lassitude over the whole body. Sometimes cold shiverings are felt; at least the body is more sensible than usual to the coldness of the air; and with all this the pulse is more frequent than ordinary, especially in the evenings.

These symptoms have seldom continued long before they are accompanied with some hoarseness, and a sense of roughness and soreness in the trachea, with some difficulty of breathing, expressed by a sense of straitness in the chest, and with a cough which seems to arise from some irritation felt at the glottis. This cough is generally at first dry and painful, occasioning pains about the chest, and more especially in the breast; sometimes, together with these symptoms, pains resembling those of the rheumatism are felt in several parts of the body, particularly about the neck and head. With all these symptoms, the appetite is impaired, some thirst arises, and a feverish lassitude is felt all over the body. These symptoms mark the height and violence of the disease; but commonly it does not continue long. By degrees the cough comes to be attended with a more copious excretion of mucus; which is at first thin, but gradually becoming thicker, is brought up with less frequent and less laborious coughing. The hoarseness and soreness of the trachea are also relieved or removed; and the febrile symptoms abating, the expectoration becomes again less considerable, and the cough less frequent, till at length they cease altogether.

Catarrh.

Such is generally the course of this disease, neither tedious nor dangerous; but it is sometimes in both respects otherwise. The body subjected to catarrh seems to be more than usually liable to be affected by cold air; and upon exposure of the body to fresh cold, the disease, which seemed to be yielding, is often brought back with greater violence than before, and is rendered not only more tedious than otherwise it would be, but also more dangerous by the supervening of other diseases. Some degree of the cynanche tonsillaris often accompanies the catarrh; and when this is aggravated by a fresh application of cold, the cynanche also becomes more violent and dangerous from the cough which is present at the same time. When a catarrh has been occasioned by a violent cause, when it has been aggravated by improper management, and especially when it has been rendered more violent by fresh and repeated applications of cold, it often passes into a pneumonic inflammation, attended with the utmost danger.

Unless, however, such accidents as these happen, a catarrh, in sound persons not far advanced in life, is always a slight and safe disease: but in persons of a phthisical disposition, a catarrh may readily produce a hæmoptysis, or perhaps form tubercles, in the lungs; and still more readily in persons who have tubercles already formed in the lungs, an accidental catarrh may occasion the inflammation of these tubercles, and in consequence produce a phthisis pulmonalis.

In elderly persons, a catarrh sometimes proves a dangerous disease. Many persons, as they advance in life, and especially after they have arrived at old age, have the natural mucus of the lungs poured out in greater quantity, and requiring a frequent expectoration. If, therefore, a catarrh happen to such persons, and increase the afflux of fluids to the lungs, with some degree of inflammation, it may produce the peripneumonia notha, or more properly chronic catarrh, a disease continuing often for many years, or at least returning regularly every winter; which in such cases is very often fatal.

Causes, &c. The proximate cause of catarrh seems to be an increased afflux of fluids to the mucous membrane of the nose, fauces, and bronchiæ, along with some degreee of inflammation affecting the same. The latter circumstance is confirmed by this, that, in the case of catarrh, the blood drawn from a vein commonly exhibits the same inflammatory crust which appears in the case of phlegmasiæ. The remote cause of catarrh is most commonly cold applied to the body. This application of cold producing catarrh is generally evident; and Dr Cullen is of opinion that it would always be so, were men acquainted with and attentive to the circumstances which determine cold to act upon the body.

The application of cold which occasions a catarrh probably operates by stopping the discharge usually made

made by the skin, and which is therefore determined to the mucous membrane of the parts above mentioned. As a part of the weight which the body daily loses by insensible evacuation, is owing to an exhalation from the lungs, there is probably a connexion between this exhalation and the cutaneous perspiration, so that the one may be increased according as the other is diminished; and therefore we may understand how the diminution of cutaneous perspiration, by the application of cold, may increase the afflux of fluids to the lungs, and thereby produce a catarrh.

Dr Cullen remarks that there are some observations of Dr James Keil which may render this matter doubtful; but says there is a fallacy in those observations. The evident effects of cold in producing coryza, leave the matter, in general, without doubt; and there are several other observations which show a connexion between the lungs and the surface of the body.

Whether from the suppression of perspiration, a catarrh be produced merely by an increased afflux of fluids, or whether in addition to this the matter of perspiration be at the same time determined to the mucous glands, and there excites a particular irritation, may be uncertain; but Dr Cullen thinks the latter supposition is most probable.

Although in the case of a common catarrh, which is in many instances sporadic, it may be doubtful whether any morbific matter be applied to the mucous glands; yet we are certain that the symptoms of a catarrh do frequently depend upon such a matter being applied to these glands, as appears from the case of measles, chincough, and especially from the frequent occurrence of contagious and epidemical catarrh.

The phenomena of contagious catarrhs have been much the same with those of the others; and the disease has always been particularly remarkable for this, that it has been the most widely and generally spreading epidemic known. It has seldom appeared in any one country of Europe, without appearing successively in almost every different part of it; and, in some instances, it has been also transferred to America, and has been spread there in like manner, so far as we have had opportunities of being informed.

The catarrh from contagion appears with nearly the same symptoms as those above mentioned. It seems often to come on in consequence of the application of cold. And indeed catarrh from cold and contagion are in every respect so similar, that when this epidemic rages, it is impossible to determine with a person having symptoms of catarrh after exposure to cold, whether the disease proceeds from the one cause or the other. In most instances, however, catarrh from contagion comes on with more cold shivering than the catarrh arising from cold alone; and the former does also not only sooner show febrile symptoms, but to a more considerable degree. Accordingly, it more speedily runs its course, which is commonly finished in a few days. It sometimes ends by a spontaneous sweat; and this, in some persons, produces a miliary eruption. It is, however, the febrile state of this disease especially that is finished in a few days; for the cough and other catarrhal symptoms do frequently continue longer, and often when they appear to be going off they are renewed by any fresh application of cold.

Prognosis. Considering the number of persons who are affected with catarrh, of either the one species or the other, and escape from it quickly without any hurt, it may be allowed to be a disease commonly free from danger: but it is not always to be treated as such; for in some persons it is accompanied with pneumonic inflammation. In the phthisically disposed, it often accelerates the coming on of phthisis; and in elderly persons it often proves fatal in the manner we have explained above, viz. by degenerating into its chronic state. But though chronic catarrh be often the termination of that species which arises from cold, we have not, in any case, observed it to arise as a consequence of a catarrh from contagion. This species of catarrh, however, is not unfrequently followed by phthisis; or rather, where a phthisical tendency before existed, the affection has been begun and its progress accelerated from this cause.

Cure. The cure of catarrh is nearly the same, whether it proceeds from cold or contagion; only in the latter case remedies are commonly more necessary than in the former. In the cases of a moderate disease, it is commonly sufficient to avoid cold, or to abstain from animal food for some days. In some cases, where the febrile symptoms are considerable, it is proper for that length of time to lie in bed, and, by taking frequently some mild and diluted drink, a little warmed, to promote a very gentle sweat; and after this to take care to return very gradually only to the use of the free air. When the disease is more violent, not only the antiphlogistic regimen, exactly observed, but various remedies also, become necessary. To take off the phlogistic diathesis which always attends this disease, blood-letting, more or less, according as the symptoms shall require, is the proper remedy. After blood-letting, for restoring the determination of the fluids to the surface of the body, and at the same time for expediting the secretion of mucus in the lungs, which may take off the inflammation of its membrane, vomiting is the most effectual means. For the last-mentioned purpose, it has been supposed that squills, gum-ammoniac, the volatile alkali, and some other medicines, might be useful; but their efficacy has never been found considerable: and if squills have ever been very useful, it seems to have been rather by their emetic than by their expectorant powers. When the inflammatory affections of the lungs seem to be considerable, it is proper, besides blood-letting, to apply blisters to the back or sides.

As a cough is often the most troublesome circumstance of this disease, so demulcents may be employed to alleviate it. But after the inflammatory symptoms are much abated, if the cough still remains, opiates afford the most effectual means of relieving it; and, in the circumstances just now mentioned, they may be very safely employed. Very considerable advantage is often derived from employing opiates in such a manner as to act more immediately on the head of the wind-pipe. For this purpose, opium may often be advantageously conjoined with demulcents, melting slowly in the mouth. And perhaps no form is more convenient, or answers the purpose better, than the *trochisci glycyrrhizæ cum opio* of the Edinburgh Pharmacopœia, Profluvia. macopœia, where purified opium is combined with extract of liquorice, gum arabic, and other demulcents, to the extent of about a grain in a dram of the composition. After the inflammatory and febrile states of this disease are very much gone, the most effectual means of discussing all remains of the catarrhal affection is by some exercise of gestation diligently employed.

Besides the remedies above mentioned, Dr Mudge, in a treatise on this disease, recommends the steam of warm water as a most efficacious and safe remedy for a catarrh, and which indeed he seems to consider as little less than *infallible*. The method of breathing in these steams is described under the word INHALER; but he gives a caution to people in health, who may accidentally see his machine, not to make the experiment of breathing through cold water with it, or they will be almost certain of catching a severe cold. His directions for those troubled with the catarrh are as follow:

"In the evening, a little before bedtime, the patient, if of adult age, is to take three drams, or as many tea-spoonfuls, of elixir paregoricum, in a glass of water: if the subject be younger, for instance under five years old, one tea-spoonful; or between that and ten years, two. About three quarters of an hour after, the patient should go to bed, and, being covered warm, the inhaler three parts filled with water nearly boiling (which, from the coldness of the metal, and the time it ordinarily takes before it is to be used by the patient, will be of a proper degree of warmth), and being wrapped up in a napkin, but so that the valve in the cover is not obstructed by it, is to be placed at the arm-pit, and the bedclothes being drawn up and over it close to the throat, the tube is to be applied to the mouth, and the patient should inspire and expire through it for about twenty minutes or half an hour.

"It is very evident, as the whole act of respiration is performed through the machine, that in inspiration the lungs will be filled with air which will be hot, and loaded with vapour, by passing through the body of water; and in exspiration, all that was contained in the lungs will, by mixing with the steam on the surface of the water, be forced through the valve in the cover, and settle on the surface of the body under the bedclothes.

"The great use of this particular construction of the inhaler is this: First, As there is no necessity, at the end of every inspiration, to remove the tube from the mouth, in order to expire from the lungs the vapour which had been received into them, this machine may therefore be used with as much ease by children as older people. And, secondly, As a feverish habit frequently accompanies the disorder, the valve in that respect also is of the utmost importance: for a sweat, or at least a free perspiration, not only relieves the patient from the restless anxiety of a hot, dry, and sometimes parched skin, but is also, of all evacuations, the most eligible for removing the fever; and it will be generally found, that, after the inhaler so constructed has been used a few minutes, the warm vapour under the clothes will, by settling upon the trunk, produce a sweat, which will gradually extend itself to the legs and feet.

"In a catarrhous fever, or any feverish habit attending this cough, it would be proper to take a draught of warm thin whey a few minutes before the inhaler be used; and after the process is over, the sweat which it has produced may be continued by occasional small draughts of weak warm whey or barley-water. The sweating is by no means so necessary to the cure of the catarrhous cough, as that the success of the inhaler against that complaint at all depends upon it.

"After this respiratory process is over, the patient usually passes the night without the least interruption from the cough, and feels no further molestation from it than once or twice in the morning to throw off the trifling leakage which, unperceived, had dripped into the bronchiæ and vesicles during the night; the thinner parts of which being evaporated, what remains is soon got rid of by a very gentle effort.

"I cannot, however, take leave of this part of my subject, without pointedly observing, that if the patient means not to be disappointed by my assurances or his own expectations, it is essentially necessary that the following remarks, with regard to the time and manner of using this process, should be strictly attended to.

"First, That as tender valetudinary people are but too well acquainted with the first notices of the disorder, the remedy must, or ought to be, used the same evening; which will, in an ordinary seizure, be attended with an immediate cure: but if the soreness of the respiratory organs, or the petulance of the cough, show the cold which has been contracted to have been very severe, the inhaler, without the opiate, should be again repeated for the same time the next morning.

"Secondly, If the use of the inhaler, &c. be delayed till the second night, it will be always right to repeat it again the next morning without the opiate, but with it if the seizure has been violent.

"And, lastly, If the cough be of some days standing, it will be always necessary to employ both parts of the process at night and the succeeding morning, as the first simple inflammatory mischief is now most probably aggravated by an additional one of a chronic tendency.

"But if, through the want of a timely application, or a total neglect of this or any other remedy, the cough should continue to harass the patient, it is, particularly in delicate and tender constitutions, of the utmost consequence to attempt the removal of it as soon as possible, before any floating acrimony in the constitution (from the perpetual irritation) receives an habitual determination to an organ so essential to life as the lungs.

"If the patient expectorate with ease and freedom a thick and well-digested inoffensive phlegm, there is generally but little doubt of his spitting off the disorder, with common care, in a few days; and till that be accomplished, a proper dose of elixir paregoricum for a few successive nights will be found very useful in suppressing the fatiguing irritation and ineffectual cough, occasioned by a matter which, dripping in the early state of the disease into the bronchiæ during the night, is commonly at that time too thin to be discharged by these convulsive efforts.

"If, however, notwithstanding a free and copious expectoration, the cough should still continue, and the discharge,

discharge, instead of removing the complaint, should itself, by becoming a disease, be a greater expence than the constitution can well support, it is possible that a tender patient may spit off his life through a weak relaxed pair of lungs, without the least appearance of purulence, or any suspicion of suppuration. In those circumstances, besides, as was mentioned before, increasing the general perspiration by the salutary friction of a flannel waistcoat, change of situation, and more especially long journeys on horseback, conducted as much as possible through a thin, sharp, dry air, will seldom fail of removing the complaint.

"But, on the contrary, if the cough should, at the same time that it is petulant and fatiguing to the breast, continue dry, husky, and without expectoration; provided there be reason to hope that no tubercles are forming, or yet actually formed, there is not perhaps a more efficacious remedy for it than half a dram of gum-ammoniacum, with 18 or 20 drops of liquid laudanum, made into pills, and taken at bedtime, and occasionally repeated. This excellent remedy Sir John Pringle did me the honour to communicate to me; and I have accordingly found it, in a great many instances, amazingly successful, and generally very expeditiously so, for it seldom fails to produce an expectoration, and to abate the distressing fatigue of the cough. In those circumstances I have likewise found the common remedy of ʒss or ℈ij of *bals. sulph. anisat.* taken twice a-day, in a little powdered sugar or any other vehicle, a very efficacious one. I have also, many times, known a salutary revulsion made from the lungs by the simple application of a large plaster, about five or six inches diameter, of Burgundy pitch, between the shoulders; for the perspirable matter, which is locked up under it, becomes so sharp and acrid, that in a few days it seldom fails to produce a very considerable itching, some little tendency to inflammation, and very frequently a great number of boils. This application should be continued (the plaster being occasionally changed), for three weeks or a month, or longer, if the complaint be not so soon removed.

"And here I cannot help observing, that, though seemingly a trifling, it is however by no means an useless caution to the tender patient, not to expose his shoulders in bed, and during the night, to the cold; but when he lies down, to take care they be kept warm, by drawing the bedclothes up close to his back and neck.

"If, however, notwithstanding these and other means, the cough, continuing dry or unattended with a proper expectoration, should persevere in harassing the patient; if, at last, it should produce, together with a soreness, shooting pains through the breast and between the shoulders, attended also with shortness of the breath; and if, added to this, flushes of the cheeks after meals, scalding in the hands and feet, and other symptoms of a hectic, should accompany the disorder; there is certainly no time to be lost, as there is the greatest reason to apprehend that some acrimony in the habit is determined to the tender substance of the lungs, and that consequently tubercular suppurations will follow. In this critical and dangerous situation, I think I can venture to say from long experience, that, accompanied with changes of air and occasional bleedings, the patient will find his greatest security in a drain from a large scapular issue, assisted by a diet of asses milk and vegetables."

GENUS XLI. DYSENTERIA. 254

The DYSENTERY.

Dysenteria, *Sauv.* gen. 248. *Lin.* 191. *Vog.* 107. *Sag.* 183. *Hoffm.* III. 151. *Junck.* 76.

Description. The dysentery is a disease in which the patient has frequent stools, accompanied with much griping, and followed by a tenesmus. The stools, though frequent, are generally in small quantity; and the matter voided is chiefly mucus, sometimes mixed with blood. At the same time, the natural fæces seldom appear: and when they do, it is generally in a compact and hardened form, often under the form of small hardened substances known by the name of *scybala.* This disease occurs especially in summer and autumn, at the same time with autumnal intermittent and remittent fevers; and with these it is often complicated. It comes on sometimes with cold shiverings, and other symptoms of pyrexia; but more commonly the symptoms of the topical affection appear first. The belly is costive, with an unusual flatulence in the bowels. Sometimes, though more rarely, some degree of diarrhœa is the first appearance.—In most cases, the disease begins with griping, and a frequent inclination to go to stool. In indulging this, little is voided, but some tenesmus attends it. By degrees the stools become more frequent, the griping more severe, and the tenesmus more considerable.—With these symptoms there is a loss of appetite, and frequently sickness, nausea, and vomiting, also affecting the patient. At the same time there is always more or less of pyrexia present. It is sometimes of the remittent kind, and observes a tertian period.—Sometimes the pyrexia is manifestly inflammatory, and very often of a putrid kind. These febrile states continue to accompany the disease during its whole course, especially when it terminates soon in a fatal manner. In other cases, the febrile state almost entirely disappears, while the proper dysenteric symptoms remain for a long time after. In the course of the disease, whether for a shorter or a longer time, the matter voided by stool is very various. Sometimes it is merely a mucous matter, without any blood, exhibiting that disease which is named by some the *morbus mucosus,* and by others the *dysenteria alba.* For the most part, however, the mucus discharged is more or less mixed with blood. This sometimes appears only in streaks among the mucus; but at other times is more copious, giving a tinct to the whole; and upon some occasions a pure and unmixed blood is voided in considerable quantity. In other respects, the matter voided is variously changed in colour and consistence, and is commonly of a strong and unusually fetid odour. It is probable, that sometimes a genuine pus is voided, and frequently a putrid sanies, proceeding from gangrenous parts. There are very often mixed with the liquid matter some films of a membranous appearance, and frequently some small masses of a seemingly sebaceous matter. While the stools voiding these various matters, are, in many instances, exceedingly fre-

Profluvia. quent, it is seldom that natural fæces appear in them; and when they do appear, it is, as we have said, in the form of scybala, that is, in somewhat hardened, separate balls. When these are voided, whether by the efforts of nature or as solicited by art, they procure a remission of all the symptoms, and more especially of the frequent stools, griping, and tenesmus.

Accompanied with these circumstances, the disease proceeds for a longer or shorter time. When the pyrexia attending it is of a violent inflammatory kind, and more especially when it is of a very putrid nature, the disease often terminates fatally in a very few days, with all the marks of a supervening gangrene. When the febrile state is more moderate, or disappears altogether, the disease is often protracted for weeks, and even for months; but, even then, after a various duration, it often terminates fatally, and generally in consequence of a return and considerable aggravation of the inflammatory and putrid states. In some cases, the disease ceases spontaneously; the frequency of stools, the griping, and tenesmus, gradually diminishing, while natural stools return. In other cases, the disease, with moderate symptoms, continues long, and ends in a diarrhœa, sometimes accompanied with lienteric symptoms.

Causes, &c. The remote causes of this disease have been variously represented. In general it arises in summer or autumn, after considerable heats have prevailed for some time, and especially after very warm and at the same time very dry states of the weather: and the disease is much more frequent in warm than in cooler climates. It happens, therefore, in the same circumstances and seasons which considerably affect the state of the bile in the human body; but the cholera is often without any dysenteric symptoms, and copious discharges of bile have been found to relieve the symptoms of dysentery; so that it is difficult to determine what connection the disease has with the state of the bile.

It has been observed, that the effluvia from very putrid animal substances ready affect the alimentary canal, and, upon occasion, they certainly produce a diarrhœa; but whether they ever produce a genuine dysentery, is not certain.

The dysentery does often manifestly arise from the application of cold, but the disease is always contagious; and, by the propagation of such contagion, independent of cold, or other exciting causes, it becomes epidemic in camps and other places. It is, therefore, to be doubted if the application of cold ever produces the disease, unless where the specific contagion has been previously received into the body; and, upon the whole, it is probable that a specific contagion is to be considered as being always the remote cause of this disease.

Whether this contagion, like many others, be of a permanent nature, and only shows its effects in certain circumstances which render it active, or if it be occasionally produced, we cannot determine. Neither, if the latter supposition be received, can we say by what means it may be generated. As little do we know any thing of its nature, considered in itself; or at most, only this, that in common with many other contagions, it is very often somewhat of a putrid nature, and capable of inducing a putrescent tendency in the human body. This, however, does not at all explain the peculiar effect of inducing those symptoms which properly and essentially constitute dysentery. Of these symptoms the proximate cause is still obscure.—The common opinion has been, that the disease depends upon an acrid matter thrown upon or somehow generated in the intestines, exciting their peristaltic motion, and thereby producing the frequent stools which occur in this disease. But this supposition cannot be adopted; for, in all the instances known, of acrid substances applied to the intestines, and producing frequent stools, they at the same time produce copious stools, as might be expected from acrid substances applied to any length of the intestines. This, however, is not the case in dysentery, in which the stools, however frequent, are generally in very small quantity, and such as may be supposed to proceed from the lower parts of the rectum only. With respect to the superior portions of the intestines, and particularly those of the colon, it is probable they are under a preternatural and considerable degree of constriction: for, as we have said above, the natural fæces are seldom voided; and when they are, it is in a form which gives reason to suppose they have been long retained in the cells of the colon, and consequently that the colon had been affected with a preternatural constriction. This is confirmed by almost all the dissections which have been made of the bodies of dysenteric patients; in which, when gangrene had not entirely destroyed the texture and form of the parts, large portions of the great guts have been found affected with a very considerable constriction.

Dysentery. The proximate cause of dysentery, or at least the chief part of the proximate cause, seems to consist in a preternatural constriction of the colon, occasioning, at the same time, those spasmodic efforts which are felt in severe gripings, and which efforts, propagated downwards to the rectum, occasion there the frequent mucous stools and tenesmus. But whether this explanation shall be admitted or not, it will still remain certain, that hardened fæces, retained in the colon, are the cause of the gripings, frequent stools, and tenesmus; for the evacuation of these fæces, whether by nature or by art, gives relief from the symptoms mentioned; and it will be more fully and usefully confirmed by this, that the most immediate and successful cure of dysentery is obtained by an early and constant attention to the preventing the constriction, and the frequent stagnation of fæces in the colon.

Cure. In the early periods of this disease, the objects chiefly to be aimed at are the following: The discharge of acrid matter deposited in the alimentary canal; the counteracting the influence of this matter when it cannot be evacuated; the obviating the effects resulting from such acrid matter as can neither be evacuated nor destroyed; and, finally, the prevention of any further separation and deposition of such matter in the alimentary canal. In the more advanced periods of the disease, the principal objects are, the giving a proper defence to the intestines against irritating causes; the diminution of the morbid sensibility of the intestinal canal: and the restoration of due vigour to the system in general, but to the intestines in particular.

The most eminent of our late practitioners, and of of greatest experience in this disease, seem to be of opinion, that it is to be cured most effectually by purging, assiduously employed. The means may be various; but the most gentle laxatives are usually sufficient; and, as the medicine must be frequently repeated, these are the more safe, more especially as an inflammatory state so frequently accompanies the disease. Whatever laxatives produce an evacuation of natural fæces, and a consequent remission of the symptoms, will be sufficient to effectuate the cure. But if the gentle laxatives shall not produce the evacuation now mentioned, somewhat more powerful must be employed; and Dr Cullen has found nothing more proper or convenient than tartar emetic, given in small doses, and at such intervals as may determine its operation to be chiefly by stool. To the tartrite of antimony, however, employed as a purgative, the great sickness which it is apt to occasion, and the tendency which it has, notwithstanding every precaution, to operate as an emetic, are certainly objections. Another antimonial, at one time considered as an almost infallible remedy for this disease, the vitrum antimonii ceratum, is no less exceptionable, from the uncertainty and violence of its operation; and perhaps the safest and best purgatives are the different neutral salts, particularly those containing fossil alkali, such as the soda vitriolata tartarisata or phosphorata. Rhubarb, so frequently employed, is, Dr Cullen thinks, in several respects, amongst the most unfit purgatives; and indeed from its astringent quality, it is exceptionable at the commencement of the affection, unless it be conjoined with something to render its operation more brisk, such as mild muriated mercury, or calomel as it it is commonly called.

Vomiting has been held a principal remedy in this disease; and may be usefully employed in the beginning, with a view both to the state of the stomach and of the fever: but it is not necessary to repeat it often; and, unless the emetics employed operate also by stool, they are of little service. Ipecacuanha is by no means a specific; and it proves only useful when so managed as to operate chiefly by stool.

For relieving the constriction of the colon, and evacuating the retained fæces, clysters may sometimes be useful; but they are seldom so effectual as laxatives given by the mouth; and acrid clysters, if they be not effectual in evacuating the colon, may prove hurtful by stimulating the rectum too much.

The frequent and severe griping attending this disease, leads almost necessarily to the use of opiates; and they are very effectual for the purpose of relieving from the gripes: but, by occasioning an interruption of the action of the small intestines, they favour the constriction of the colon, and thereby aggravate the disease; and if, at the same time, the use of them supersede in any measure the employing purgatives, it is doing much mischief; and the neglect of purging seems to be the only thing which renders the use of opiates very necessary.

When the gripes are both frequent and severe, they may sometimes be relieved by the employment of the semicupium, or by fomentation of the abdomen continued for some time. In the same case, the pains may be relieved, and the constriction of the colon may be taken off, by blisters applied to the lower belly.

At the beginning of this disease, when the fever is any way considerable, bloodletting, in patients of tolerable vigour, may be proper and necessary; and, when the pulse is full and hard, with other symptoms of an inflammatory disposition, bloodletting ought to be repeated. But as the fever attending dysentery is often of the typhoid kind, or does, in the course of the disease, become soon of that nature, bloodletting must be cautiously employed.

From our account of the nature of this disease, it will be sufficiently obvious, that the use of astringents in the beginning of it must be very pernicious. But although astringents may be hurtful at early periods of this affection, yet it cannot be denied, that where frequent loose stools remain after the febrile symptoms have subsided, they are often of great service for diminishing morbid sensibility, and restoring due vigour to the intestinal canal. Accordingly, on this ground a variety of articles have been highly celebrated in this affection; among others we may mention the quassia, radix indica lopeziana, verbascum, extractum catechu, and gum kino, all of which have certainly in particular cases been employed with great advantage. And perhaps also, on the same principles we are to account for the benefit which has been sometimes derived from the nux vomica, a remedy highly extolled in cases of dysentery by some of the Swedish physicians; but this article, it must be allowed, often proves very powerful as an evacuant. Its effects, however, whatever its mode of operation may be, are too precarious to allow its ever being introduced into common practice; and in this country, it has, we believe, been but very rarely employed. Whether an acrid matter be the original cause of the dysentery, may be uncertain; but, from the indigestion, and the stagnation of fluids, which attend the disease, we may suppose that some acrid matters are constantly present in the stomach and intestines; and therefore that demulcents may be always usefully employed. At the same time, from the consideration that mild oily matters thrown into the intestines in considerable quantity always prove laxative, Dr Cullen is of opinion, that the oleaginous demulcents are the most useful. Where, however, these are not acceptable to the patient's taste, those of the mucilaginous and farinaceous kind, as the decoctum hordei, potio cretacea, &c. are often employed with advantage.

As this disease is so often of an inflammatory or of a putrid nature, it is evident that the diet employed in it should be vegetable and acescent. Milk, in its entire state, is of doubtful quality in many cases; but even some portion of the cream is often allowable, and whey is always proper.—In the first stages of the disease, the sweet and subacid fruits are allowable and even proper. It is in the more advanced stages only that any morbid acidity seems to prevail in the stomach, and to require some reserve in the use of acescents. At the beginning of the disease, absorbents seem to be superfluous; and, by their astringent and septic powers, they may be hurtful; but in after periods they are often of advantage.

When this disease is complicated with an intermittent, Comata. tent, and is protracted from that circumstance chiefly, it is to be treated as an intermittent, by administering the cinchona, which in the earlier periods of the disease is hardly to be admitted.

Class II. NEUROSES.

Order I. COMATA.

Comata, *Sauv.* Class VI. Ord. II. *Sag.* Class IX. Order V.
Soporosi, *Lin.* Class VI. Ord. II.
Adynamiæ, *Vog.* Class VI.
Nervorum resolutiones, *Hoffm.* III. 194.
Affectus soporosi, *Hoffm.* III. 209.
Motuum vitalium defectus, *Junck.* 114.

255 Genus XLII. APOPLEXIA.

The Apoplexy.

Apoplexia, *Sauv.* gen. 182. *Lin.* 101. *Vog.* 229. *Boerh.* 1007. *Junck.* 117. *Sag.* gen. 288. *Wepfer.* Hist. apoplecticorum.
Carus, *Sauv.* gen. 181. *Lin.* 100. *Vog.* 231. *Boerh.* 1045. *Sag.* gen. 287.
Cataphora, *Sauv.* gen. 180. *Lin.* 99. *Vog.* 232. *Boerh.* 1045. *Sag.* gen. 286.
Coma, *Vog.* 232. *Boerh.* 1048.
Hæmorrhagia cerebri, *Hoffm.* II. 240.

To this genus also Dr Cullen reckons the following diseases to belong :

Catalepsis, *Sauv.* gen. 176. *Lin.* 129. *Vog.* 230. *Sag.* gen. 281. *Boerh.* 1036. *Junck.* 44.
Affectus cerebri spasmodico-ecstaticus, *Hoffm.* III. 44.
Ecstasis, *Sauv.* gen. 177. *Vog.* 333. *Sag.* gen. 283.

The following he reckons symptomatic :

Typhomania, *Sauv.* gen. 178. *Lin.* 97. *Vog.* 23. *Sag.* gen. 284.
Lethargus, *Sauv.* gen. 179. *Lin.* 98. *Vog.* 22. *Sag.* gen. 285.

This disease appears under modifications so various, as to require some observations with respect to each.

256 Sp. I. The *Sanguineous Apoplexy.*

Description. In this disease the patients fall suddenly down, and are deprived of all sense and voluntary motion, but without convulsions. A giddiness of the head, noise in the ears, coruscations before the eyes, and redness of the face, usually precede. The distinguishing symptom of the disease is a deep sleep, attended with violent snorting ; if any thing be put into the mouth, it is returned through the nose ; nor can any thing be swallowed without shutting the nostrils ; and even when this is done, the person is in the utmost danger of suffocation. Sometimes apoplectic patients will open their eyes after having taken a large dose of an emetic ; but if they show no sign of sense, there is not the least hope of their recovery. Sometimes the apoplexy terminates in a hemiplegia ; in which case it comes on with a distortion of the mouth towards the sound side, Apoplex a drawing of the tongue the same way, and stammering of the speech. Dissections sometimes show a rupture of some vessels of the meninges, or even vessels of the brain itself ; though sometimes, if we may believe Dr Willis, no defect is to be observed either in the cerebrum or cerebellum.

Causes, &c. The general cause of a sanguineous apoplexy is a plethoric habit of body, with a determination to the head. The disease therefore may be brought on by whatever violently urges on the circulation of the blood ; such as surfeits, intoxication, violent passions of the mind, immoderate exercise, &c. It takes place, however, for the most part, when the venous plethora has subsisted for a considerable time in the system. For that reason it commonly does not attack people till past the age of 60 ; and that whether the patients are corpulent and have a short neck, or whether they are of a lean habit of body. Till people be past the age of childhood, apoplexy never happens.

Prognosis. This disease very often kills at its first attack, and few survive a repetition of the fit ; so that those who make mention of people who have survived several attacks of the apoplexy, have probably mistaken the epilepsy for this disease. In no disease is the prognosis more fatal ; since those who seem to be recovering from a fit, are frequently and suddenly carried off by its return, without either warning of its approach or possibility of preventing it. The good signs are when the disease apparently wears off, and the patient evidently begins to recover ; the bad ones are when all the symptoms continue and increase.

Cure. The great object to be aimed at, is to restore the connection between the sentient and corporeal parts of the system ; and when interruption to this connexion proceeds from compression in the brain by blood, this is to be attempted, in the first place, by large and repeated bleedings ; after which, the same remedies are to be used as in the serous apoplexy, after mentioned. The body is to be kept in a somewhat erect posture, and the head supported in that situation.

Sp. II. The *Serous Apoplexy.* 25

Apoplexia pituitosa, *Sauv.* sp. 7. Apoplexia serosa, *Preysinger.* sp. 4. *Morg.* de causis, &c. IV. LX.
Carus à hydrocephalo, *Sauv.* sp. 16.
Cataphora hydrocephalica, *Sauv.* sp. 6.
Cataphora somnolenta, *Sauv.* sp. 1.
Lethargus literatorum, *Sauv.* 7. *Van Swieten* in Aphor. 1010. 2γ and 3α.

Description. In this species the pulse is weak, the face pale, and there is a diminution of the natural heat. On dissection, the ventricles of the brain are found to contain a larger quantity of fluid than they ought ; the other symptoms are the same as in the former.

Causes, &c. This may arise from any thing which induces a debilitated state of the body, such as depressing passions of the mind, much study, watching, &c. It may also be brought on by a too plentiful use of diluting, acidulated drinks. It doth not, however,

ever, follow, that the extravasated serum above mentioned in the ventricles of the brain is always the cause of the disease, since the animal fluids are very frequently observed to ooze out in plenty through the coats of the containing vessels after death, though no extravasation took place during life.

Prognosis. This species is equally fatal with the other; and what hath been said of the prognosis of the sanguineous, may also be said of that of the serous apoplexy.

Cure. In this species venesection can scarcely be admitted: acrid purgatives, emetics, and stimulating clysters, are recommended to carry off the superabundant serum; but in bodies already debilitated, they may perhaps be liable to the same exceptions with venesection itself. Volatile salts, cephalic elixirs, and cordials, are also prescribed; and in case of a hemiplegia supervening, the cure is to be attempted by aperient ptisans, cathartics, and sudorifics; gentle exercise, as riding in a carriage; with blisters and such stimulating medicines as are in general had recourse to in affections originally of the paralytic kind.

158 Sp. III. *Hydrocephalic* APOPLEXY, or *Dropsy* of the *Brain.*

Hydrocephalus interior, *Sauv.* sp. 1.
Hydrocephalus internus, *Whytt's* works, page 725.
London Med. Obs. vol. iv. art. 3, 6, and 25.
Gaudelius de hydrocephalo, apud *Sandifort* Thesaur. vol. ii.
Hydrocephalus acutus, *Quin. Diss.* de hydrocephalo, 1779.
Asthenia à hydrocephalo, *Sauv.* sp. 3.

History and description. This disease has been accurately treated within these few years by several eminent physicians, particularly the late Dr Whytt, Dr Fothergill, and Dr Watson; who concur in opinion, with respect to the seat of the complaint, the most of its symptoms, and its general fatality. Out of twenty patients that had fallen under Dr Whytt's observation, he candidly owns that he had been so unfortunate as to cure only one who laboured under the characteristic symptoms of the hydrocephalus; and he suspects that those who imagine they have been more successful, had mistaken another distemper for this. It is by all supposed to consist in a dropsy of the ventricles of the brain; and this opinion is fully established by dissections. It is observed to happen more commonly to healthy, active, lively children, than to those of a different disposition.

Dr Whytt supposes that the commencement of this disease is obscure; that it is generally some months in forming; and that, after some obvious urgent symptoms rendering assistance necessary, it continues some weeks before its fatal termination. This, in general, differs from what has hitherto been observed by Dr Fothergill; the latter informing us, that he has seen children, who, from all appearance, were healthy and active, seized with this distemper, and carried off in about 14 days. He has seldom been able to trace the commencement of it above three weeks.

Though the hydrocephalus be most incident to children, it has been sometimes observed in adults; as appears from a case related by Dr Huck, and from some others.

When the disease appears under its most common form, the symptoms at different periods are so various as to lead Dr Whytt to divide the disease into three stages, which are chiefly marked by changes occurring in the condition of the pulse. At the beginning it is quicker than natural; afterwards it becomes uncommonly slow; and towards the conclusion of the disease it becomes again quicker than natural, but at the same time often very irregular.

Those who are seized with this distemper usually complain first of a pain in some part below the head; most commonly about the nape of the neck and shoulders; often in the legs; and sometimes, but more rarely, in the arms. The pain is not uniformly acute, nor always fixed to one place; and sometimes does not affect the limbs. In the latter case, the head and stomach have been found to be most disordered; so that when the pain occupied the limbs, the sickness or headach was less considerable; and when the head became the seat of the complaint, the pain in the limbs was seldom or never mentioned. Some had very violent sicknesses and violent headachs alternately. From being perfectly well and sportive, some were in a few hours seized with those pains in the limbs, or with sickness, or headach, in a slight degree, commonly after dinner; but some were observed to droop a few days before they complained of any local indisposition. In this manner they continued three, four, or five days, more or less, as the children were healthy and vigorous. They then commonly complain of an acute deep-seated pain in the head, extending across the forehead from temple to temple; of which, and a sickness, they alternately complain in short and affecting exclamations; dosing a little in the intervals, breathing irregularly, and sighing much while awake. Sometimes their sighs, for the space of a few minutes, are incessant.

As the disease advances, the pulse becomes slower and irregular, the strokes being made both with unequal force and in unequal times, till within a day or two of the fatal termination of the disorder, when it becomes exceeding quick; the breathing being at the same time deep, irregular, and laborious. After the first attack, which is often attended with feverish heats, especially towards evening, the heat of the body is for the most part temperate, till at last it keeps pace with the increasing quickness of the pulse. The head and præcordia are always hot from the first attack. The sleeps are short and disturbed, sometimes interrupted by watchfulness; besides which there are startings.

In the first stage of the disease there seems to be a peculiar sensibility of the eyes, as appears from the intolerance of light. But in the progress of the disease a very opposite state occurs: The pupil is remarkably dilated, and cannot be made to contract by the action even of strong light; such, for example, as by bringing a candle very near to it. In many cases there is reason to believe that total blindness occurs: Often also the pupil of one eye is more dilated than that of another, and the power of moving the eyes is also morbidly affected. Those children, who were never observed to squint before, often become affected with

Comata.

with a very great degree of strabismus. The patients are unwilling to be disturbed for any purpose, and can bear no posture but that of lying horizontally. One or both hands are most commonly about their heads. The urine and stools come away insensibly. At length the eyelids become paralytic, great heat accompanied with sweat overspreads the whole body, respiration is rendered totally suspirious, the pulse increases in its trembling undulations beyond the possibility of counting, till the vital motions entirely cease; and sometimes convulsions conclude the scene.

Many of the symptoms above enumerated are so common to worm cases, teething, and other irritating causes, that it is difficult to fix upon any which particularly characterize this disease at its commencement. The most peculiar seem to be the pains in the limbs, with sickness and incessant headach; which, though frequent in other diseases of children, are neither so uniformly nor so constantly attendant as in this. Another circumstance observed to be familiar, if not peculiar to this distemper, is, that the patients are not only costive, but it is likewise with the greatest difficulty that stools can be procured. These are generally of a very dark greenish colour with an oiliness or a glassy bile, rather than the slime which accompanies worms; and they are, for the most part, extremely offensive. No positive conclusion can be drawn from the appearance of the urine; it being various, in different subjects, both in its colour and contents, according to the quantity of liquor they drank, and the time between the discharges of the urine. From their unwillingness to be moved, they often retain their water 12 or 15 hours, and sometimes longer. In complaints arising from worms, and in dentition, convulsions are more frequent than in this disorder. Children subject to fits are sometimes seized with them a few days before they die. Sometimes these continue 24 hours incessantly, and till they expire.

Causes. The causes of internal hydrocephalus are very much unknown. Some suppose it to proceed from a rupture of some of the lymphatic vessels of the brain. But this supposition is so far from being confirmed by any anatomical observation, that even the existence of such vessels in the brain is not clearly demonstrated. That lymphatics, however, do exist in the brain, cannot be doubted; and one of the most probable causes giving rise to an accumulation of water in the brain is a diminished action of these. Here, however, as well as in other places, accumulation may also be the consequence of augmented effusion; and in this way, an inflammatory disposition, as some have supposed, may give rise to the affection. But from whatever cause an accumulation of water in the ventricles of the brain be produced, there can be no doubt that from this the principal symptoms of the disease, arise, and that a cure is to be accomplished only by the removal of it. It is, however, probable, that the symptoms are somewhat varied by the position of the water, and that the affection of vision in particular is often the consequence of some morbid state about the *thalami nervorum opticorum;* at least, in many cases, large collections of water in the ventricles have occurred, without either strabismus, intolerance of light, or dilatation of the pupil. And in cases where these symptoms have taken place to a remarkable degree, while upon dissection after death but a very small collection of water was found in the ventricles, it has been observed, that a peculiar tumid appearance was discovered about the optic nerves, which upon examination was found to arise from water in the cellular texture. This may have given compression producing a state of insensibility; but it may have been preceded, or it may even have originated from some inflammatory affection of these parts, producing the intolerance of light.

Apoplexia.

Prognosis and Cure. Till very lately this disorder was reckoned totally incurable; but of late it has been alleged, that mercury, if applied in time, will remove every symptom. This remedy was first suggested by Dr Dobson of Liverpool, and afterwards employed apparently with success by Dr Percival, Dr Makie, and others. But the practice has by no means been found to be generally successful. In a great majority of instances, after mercury has had the fairest trial, the disorder has proved fatal. And it is a very remarkable circumstance, that in this disease, after great quantities of mercury have been used both externally and internally, it rarely affects the mouth. But even in cases where salivation has been induced, a fatal conclusion has yet ensued.

Of late the digitalis purpurea has been thought, in some cases of hydrocephalus, as well as in other obstinate dropsies, to be employed with benefit. But this also, in the hands of most practitioners, has very generally failed. Perhaps there is no remedy from which benefit has more frequently been observed than from blisters. But we may conclude with observing, that the cure of the apoplexia hydrocephalica still remains to be discovered.

Sp. IV. Apoplexy *from Atrabilis.* 259

Apoplexia atrabiliaris, *Sauv.* sp. 12. *Preysinger.* sp. 6.

This takes place in the last stage of the diffusion of bile through the system, i. e. of the black jaundice; and in some cases the brain has been found quite tinged brown. It cannot be thought to admit of any cure.

Sp. V. Apoplexy *from External Violence.* 260

Apoplexia traumatica, *Sauv.* sp. 2.
Carus traumaticus, *Sauv.* sp. 5.

The treatment of this disease, as it arises from some external injury, properly falls under the article Surgery.

Sp. VI. Apoplexy *from Poisons.* 261

Apoplexia temulenta, *Sauv.* sp. 3.
Carus à narcoticis, *Sauv.* sp. 14.
Lethargus à narcoticis, *Sauv.* sp. 3.
Carus à plumbagine, *Sauv.* sp. 10.
Apoplexia mephitica, *Sauv.* sp. 14.
Asphyxia à mephitide, *Sauv.* sp. 9.
Asphyxia à musto, *Sauv.* sp. 3.
Catalepsis à fumo, *Sauv.* sp. 3.
Asphyxia à fumis, *Sauv.* sp. 2.
Asphyxia à carbone, *Sauv.* sp. 16.
Asphyxia foricariorum, *Sauv.* sp. 11.
Asphyxia sideratorum, *Sauv.* sp. 10.
Carus ab insolatione, *Sauv.* sp. 12.

Carus à frigore, *Sauv.* sp. 15.
Lethargus à frigore, *Sauv.* sp. 6.
Asphyxia congelatorum, *Sauv.* sp. 5.

The poisons which bring on an apoplexy when taken internally may be either of the stimulant or sedative kind, as spirituous liquors, opium, and the more virulent kinds of vegetable poisons. The vapours of mercury, or of lead, in great quantity, will sometimes produce a similar effect; though commonly they produce rather a paralysis, and operate slowly. The vapours of charcoal, or fixed air, in any form, breathed in great quantity, also produce an apoplexy, or a state very similar to it; and even cold itself produces a fatal sleep, though without the apoplectic stertor. To enumerate all the different symptoms which affect the unhappy persons who have swallowed opium, or any of the stronger vegetable narcotics, is impossible, as they are scarcely to be found the same in any two patients. The state induced by them seems to differ somewhat from that of a true apoplexy; as it is commonly attended with convulsions, but has the particular distinguishing sign of apoplexy, namely, a very difficult breathing or snorting, more or less violent according to the quantity of poisonous matter swallowed.

Of the poisonous effects of fixed air, Dr Percival gives the following account. "All these noxious vapours, whether arising from burning charcoal, the fermenting grape, the Grotti di Cani, or the cavern of Pyrmont, operate nearly in the same manner. When accumulated and confined, their effects are often instantaneous: they immediately destroy the action of the brain and nerves, and in a moment arrest the vital motions. When more diffused, their effects are slower, but still evidently mark out a direct affection of the nervous system.

"Those who are exposed to the vapours of the fermenting grape, are as instantly destroyed as they would be by the strongest electrical shock. A state of insensibility is the immediate effect upon those animals which are thrust into the Grotti di Cani, or the cavern of Pyrmont: the animal is deprived of motion, lies as if dead; and if not quickly returned into the fresh air, is irrecoverable. And if we attend to the histories of those who have suffered from the vapours of burning charcoal, we shall in like manner find, that the brain and moving powers are the parts primarily affected.

"A cook who had been accustomed to make use of lighted charcoal more than his business required, and to stand with his head over these fires, complained for a year of very acute pain in the head; and after this was seized with a paralytic affection of the lower limbs, and a slow fever.

"A person was left reading in bed with a pan of charcoal in a corner of the room. On being visited early the next morning, he was found with his eyes shut, his book open and laid on one side, his candle extinguished, and to appearance like one in a deep sleep. Stimulants and cupping-glasses gave no relief: but he was soon recovered by the free access of fresh air.

"Four prisoners, in order to make their escape, attempted to destroy the iron-work of their windows, by the means of burning charcoal. As soon as they commenced their operation, the fumes of the charcoal being confined by the closeness of the prison, one of them was struck dead; another was found pale, speechless, and without motion; afterwards he spoke incoherently, was seized with a fever, and died. The other two were with great difficulty recovered.

"Two boys went to warm themselves in a stove heated with charcoal. In the morning they were found destitute of sense and motion, with countenances as composed as in a placid sleep. There were some remains of pulse, but they died in a short time.

"A fisherman deposited a large quantity of charcoal in a deep cellar. Some time afterwards his son, a healthy strong man, went down into the cellar with a pan of burning charcoal and a light in his hand. He had scarcely descended to the bottom, when his candle went out. He returned, lighted his candle, and again descended. Soon after, he called aloud for assistance. His mother, brother, and a servant, hasted to give him relief; but none of them returned. Two others of the village shared the same fate. It was then determined to throw large quantities of water into the cellar: and after two or three days they had access to the dead bodies.

"Cœlius Aurelianus says, that those who are injured by the fumes of charcoal become cataleptic. And Hoffman enumerates a train of symptoms, which in no respect correspond with his idea of suffocation. Those who suffer from the fumes of burning charcoal, says he, have severe pains in the head, great debility, faintness, stupor, and lethargy.

"It appears from the above histories and observations, that these vapours exert their noxious effects on the brain and nerves. Sometimes they occasion sudden death: at other times, the various symptoms of a debilitated nervous system, according as the poison is more or less concentrated. The olfactory nerves are first and principally affected, and the brain and nervous system by sympathy or consent of parts. It is well known, that there is a strong and ready consent between the olfactory nerves and many other parts of the nervous system. The effluvia of flowers and perfumes, in delicate or irritable habits, produce a train of symptoms, which, though transient, are analogous to those which are produced by the vapours of charcoal; viz. vertigo, sickness, faintness, and sometimes a total insensibility. The female malefactor, whom Dr Mead inoculated by putting into the nostrils dossils of cotton impregnated with variolous matter, was immediately on the introduction, afflicted with an excruciating headach, and had a constant fever till after the eruption.

"The vapours of burning charcoal, and other poisonous effluvia, frequently produce their prejudicial, and even fatal effects, without being either offensive to the smell or oppressive to the lungs. It is a matter of importance, therefore, that the common opinion should be more agreeable to truth; for where suffocation is supposed to be the effect, there will be little apprehension of danger, so long as the breast keeps free from pain or oppression.

"It may be well to remember, that the poison itself is distinct from that gross matter which is offensive to the smell; and that this is frequently in its most active state when undistinguished by the sense. Were the

Comata. the following cautions generally attended to, they might in some instances be the happy means of preserving life. Never to be confined with burning charcoal in a small room, or where there is not a free draught of air by a chimney or some other way. Never to venture into any place in which air has been long pent up, or which from other circumstances ought to be suspected; unless such suspected place be either previously well ventilated, or put to the test of the lighted candle: for it is a singular and well-known fact, that the life of flame is in some circumstances sooner affected and more expeditiously extinguished by noxious vapours than animal-life; a proof of which I remember to have received from a very intelligent clergyman, who was present at a musical entertainment in the theatre at Oxford. The theatre was crowded; and during the entertainment the candles were observed to burn dim, and some of them went out. The audience complained only of faintness and languor; but had the animal effluvia been still further accumulated or longer confined, they would have been extinguished as well as the candles.

"The most obvious, effectual, and expeditious means of relief to those who have unhappily suffered from this cause, are such as will dislodge and wash away the poison, restore the energy of the brain and nerves, and renew the vital motions. Let the patient therefore be immediately carried into the open air, and let the air be fanned backwards and forwards to assist its action; let cold water be thrown on the face; let the face, mouth, and nostrils, be repeatedly washed; and as soon as practicable, get the patient to drink some cold water. But if the case be too far gone to be thus relieved, let a healthy person breathe into the mouth of the patient; and gently force air into the mouth, throat, and nostrils. Frictions, cupping, bleeding, and blisters, are likewise indicated. And if, after the instant danger is removed, a fever be excited, the method of cure must be adapted to the nature and prevailing symptoms of the fever."

With regard to the poison of opium, Dr Mead recommends the following method of cure. Besides evacuations by vomiting, bleeding, and blistering, acid medicines and lixivial salts are proper. These contract the relaxed fibres, and by their diuretic force make a depletion of the vessels. Dr Mead says he has given repeated doses of a mixture of salt of wormwood and juice of lemons, with extraordinary success. But nothing perhaps is of greater consequence, than to use proper means for the prevention of sleep, by rousing and stirring the patient, and by forcing him to walk about; for if he be once permitted to fall into a sound sleep, it will be found altogether impossible to awake him.

Of a kind somewhat akin to the poison of opium seems to be that of laurel-water, a simple water distilled from the leaves of the lauro-cerasus or common laurel. The bad effects of this were particularly observed in Ireland, where it had been customary to mix it with brandy for the sake of the flavour; and thus two women were suddenly killed by it. This gave occasion to some experiments upon dogs, in order to ascertain the malignant qualities of the water in question; and the event was as follows: All the dogs fell immediately into totterings and convulsions of the limbs, which were soon followed by a total paralysis, so that no motion could be excited even by pricking or cutting them. No inflammation was found upon dissection, in any of the internal membranes. The most remarkable thing was a great fulness and distention of the veins, in which the blood was so fluid, that even the lymph in its vessels was generally found tinged with red. The same effects were produced by the water injected into the intestines by way of clyster.

Apoplexia.

To make the experiment more fully, Dr Nicholls prepared some of this water so strong, that about a dram of heavy essential oil remained at the bottom of three pints of it, which by frequent shaking was again quite incorporated with it. So virulent was this water, that two ounces of it killed a middle-sized dog in less than half a minute, even while it was passing down his throat. The poison appeared to reside entirely in the above-mentioned essential oil, which comes over by distillation, not only from the leaves of laurel, but from some other vegetables; for ten drops of a red oil distilled from bitter almonds, when mixed with half an ounce of water, and given to a dog, killed him in less than half an hour.

Volatile alkalies are found to be an antidote to this poison; of which Dr Mead gives the following instance. About an ounce of strong laurel-water was given to a small dog. He fell immediately into the most violent convulsions, which were soon followed by a total loss of his limbs. When he seemed to be expiring, a phial of good spirit of sal ammoniac was held to his nose, and a small quantity of the same forced down his throat: he instantly felt its virtue; and by continuing the use of it for some time, he by degrees recovered the motion of his legs; and in two hours walked about with tolerable strength, and was afterwards quite well.

With regard to the pernicious effects of cold, there is no other way of counteracting them but by the application of external heat. We are apt to imagine, that the swallowing considerable quantities of ardent spirits may be a means of making us resist the cold, and preventing the bad effects of it from arising to such a height as to destroy life; but these do not appear to be in the least possessed of any such virtue in those countries liable to great excesses of cold. The cinchona, by strengthening the solids, as well as increasing the motion of the fluids, is found to answer better than any other thing as a preservative: but when the pernicious effects have already begun to discover themselves, nothing but increasing by some means or other the heat of the body can possibly be depended upon: and even this must be attempted with great care; for as, in such cases, there is generally a tendency to mortification in some of the extremities, the sudden application of heat will certainly increase this tendency to such a degree as to destroy the parts. But for the external treatment of such mortifications, see the article SURGERY.

Sp. VII. APOPLEXY from *Passions* of the *Mind*. 262

Carus à pathemate, *Sauv.* sp. 11.
Asphyxia à pathemate, *Sauv.* sp. 7.
Ecstasis catoche, *Sauv.* sp. 1.
Ecstasis resoluta, *Sauv.* sp. 2.

Apoplexies

Apoplexies from violent passions may be either sanguineous or serous, though more commonly of the former than the latter species. The treatment is the same in either case. Or they may partake of the nature of catalepsy; in which case the method of treatment is the same with that of the genuine catalepsy.

3 Sp. VIII. The *Cataleptic* Apoplexy.

Catalepsis, *Sauv.* gen. 176. *Lin.* 129. *Vog.* 230. *Sag.* gen. 281. *Boerh.* 1036. *Junck.* 44.

Dr Cullen says he has never seen the catalepsy except when counterfeited; and is of opinion that many of those cases related by other authors have also been counterfeited. It is said to come on suddenly, being only preceded by some languor of body and mind; and to return by paroxysms. The patients are said to be for some minutes, sometimes (though rarely) for some hours, deprived of their senses, and all power of voluntary motions; but constantly retaining the position in which they were first seized, whether lying or sitting; and if the limbs be put into any other posture during the fit, they will keep the posture in which they are placed. When they recover from the paroxysm, they remember nothing of what passed during the time of it, but are like persons awaked out of sleep.—Concerning the cure of this disorder we find nothing that can be depended upon among medical writers.

4 Sp. IX. Apoplexy from *Suffocation.*

Asphyxia suspensorum, *Sauv.* sp. 4.
Asphyxia immersorum, *Sauv.* sp. 1.

This is the kind of apoplexy which takes place in those who are hanged or drowned. For the treatment of those persons, see the articles Drowning and Hanging.

Besides the species above mentioned, the apoplexy is a symptom in many other distempers, such as fevers both continued and intermitting, exanthemata, hysteria, epilepsy, gout, worms, ischuria, and scurvy.

5 Genus XLIII. PARALYSIS.

The Palsy.

Paralysis, *Boerh.* 1057.
Hemiplegia, *Sauv.* gen. 170. *Lin.* 103. *Vog.* 220.
Paraplexia, *Sauv.* gen. 171.
Paraplegia, *Lin.* 102. *Vog.* 227.
Paralysis, *Sauv.* gen. 169. *Lin.* 104. *Vog.* 226. *Junck.* 115.
Atonia, *Lin.* 120.

6 Sp. I. The *Partial Palsy.*

Paralysis, *Sauv.* gen. 169. *Lin.* 104. *Vog.* 226. *Junck.* 115.
Paralysis plethorica, *Sauv.* sp. 1.
Paralysis serosa, *Sauv.* sp. 12.
Paralysis nervea, *Sauv.* sp. 11.
Mutitas à glossolysi, *Sauv.* sp. 1.
Aphonia paralytica, *Sauv.* sp. 8.

Sp. II. Hemiplegia, or *Palsy of one side of the* Body. 267

Hemiplegia, *Sauv.* gen. 170. *Lin.* 108. *Vog.* 228. *Sag.* gen. 276.
Hemiplegia ex apoplexia, *Sauv.* sp. 7.
Hemiplegia spasmodica, *Sauv.* sp. 2.
Hemiplegia serosa, *Sauv.* sp. 10.

Sp. III. Paraplegia, or *Palsy of one half of the* Body *taken transversely.* 268

Paraplexia, *Sauv.* gen. 171. *Sag.* gen. 277.
Paraplegia, *Lin.* 102. *Vog.* 227.
Paraplexia sanguinea, *Sauv.* sp. 2.
Paraplexia à spina bifida, *Sauv.* sp. 3.
Paraplexia rheumatica, *Sauv.* sp. 1.

Description. The palsy under all the different forms here mentioned as particular species, shows itself by a sudden loss of tone and vital power in a certain part of the body. In the slighter degrees of the disease, it only affects a particular muscle, as the sphincter of the anus or bladder, thus occasioning an involuntary discharge of excrements or of urine; of the muscles of the tongue, which occasions stammering, or loss of speech; of the muscles of the larynx, by which the patient becomes unable to swallow solids, and sometimes even liquids also.—In the higher degrees of the disease, the paralytic affection is diffused over a whole limb, as the foot, leg, hand, or arm; and sometimes it affects a whole side of the body, in which case it is called *hemiplegia;* and sometimes, which is the most violent case, it affects all the parts below the waist, or even below the head, though this last be exceedingly rare. In these violent cases, the speech is either very much impeded, or totally lost. Convulsions often take place in the sound side, with the cynic spasm or involuntary laughter, and other distortions of the face. Sometimes the whole paralytic part of the body becomes livid, or even mortifies before the patient's death; and sometimes the paralytic parts gradually decay and shrivel up, so as to become much less than before. Whether the disease be more or less extended, many different varieties may be observed in its form. Sometimes there occurs a total loss of sense while motion is entire; in others a total loss of motion with very slight or even no affection of sense; and in some cases, while a total loss of motion takes place in one side, a total loss of sense has been observed on the other. This depends entirely on the particular nerves or branches of nerves in which the affection is situated; loss of sense depending on an affection of the subcutaneous nerves; and loss of motion on an affection of those leading to the muscles.

Causes, &c. Palsies most commonly supervene upon the different species of coma, especially the apoplexy. They are also occasioned by any debilitating power applied to the body, especially by excesses in venery. Sometimes they are a kind of crisis to other distempers, as the colic of Poictou, and the apoplexy. The hemiplegia especially often follows the last-mentioned disease. Aged people, and those who are by any other means debilitated, are subject to palsy; which will sometimes also affect even infants, from the repulsion of exanthemata of various kinds. Palsies are also the infallible consequences of injuries to the large nerves.

Comata.

Prognosis. Except in the slighter cases of palsy, we have little room to hope for a cure; however, death does not immediately follow even the most severe paralytic affections. In hemiplegia it is not uncommon to see the patients live several years; and even in the paraplegia, if death do not ensue within two or three weeks, it may not take place for a considerable time. It is a promising sign when the patient feels a slight degree of painful itchiness in the affected parts; and if a fever should arise, it bids fair to cure the palsy. When the sense of feeling remains, there is much more room to hope for a cure than where it is gone, as well as the power of motion. But when we observe the flesh to waste, and the skin to appear withered and dry, we may look upon the disease to be incurable. Convulsions supervening on a palsy are a fatal sign.

Cure. Many remedies have been recommended in palsies: but it must be confessed, that, except in the slighter cases, medicines seldom prove effectual; and before any plan of cure can be laid down, every circumstance relative to the patient's habit of body and previous state of health should be carefully weighed. If hemiplegia or paraplegia should come on after an apoplexy, attended with those circumstances which physicians have supposed to denote a viscid state of the blood, a course of the attenuant gums, with fixed alkaline salts, and chalybeate waters, may do service; to which it will be proper to add frictions with the volatile liniment down the spine: but in habits where the blood is rather inclined to the watery state, it will be necessary to give emetics from time to time; to apply blisters, and insert issues.

The natural hot baths are often found useful in paralytic cases; and where the patients cannot avail themselves of these, an artificial bath may be tried by dissolving salt of steel in water, and impregnating the water with fixed air. Frictions of the parts, and scourging them with nettles, have also been recommended, and may do service, as well as volatile and stimulating medicines taken inwardly. And it is probably by operating in this manner, that the use of camphor, or a mercurial course continued for some length of time to such a degree as gently to affect the mouth, have been found productive of a cure in obstinate cases of this affection. Of late years, an infusion of the arnica montana or German leopard's bane, has been highly extolled in the cure of this disease, by some foreign writers: but the trials made with it in Britain, particularly at Edinburgh, have been by no means equally successful with those related by Dr Collins, who has strongly recommended this medicine to the attention of the public. Another remedy has of late been highly extolled in palsy, the rhus toxicodendron or poison oak. It has been employed with some success in France by M. Fresnoi; and Dr Alderson of Hull, in a late dissertation on this plant, has published several cases, even of very obstinate palsy, in which its use was attended with wonderful success. In some cases also at Edinburgh, it has been used with apparent advantage, but in a much greater number without any benefit.

In certain cases of palsy, unexpected cures have been accomplished both by electricity and by galvanism. But in a considerable majority of instances, palsy from which the patient has not what may be called a natural recovery, will be found incurable by any remedies which have hitherto been recommended.

Syncope.

Sp. IV. The Palsy from *Poisons.* 269

Paralysis metallariorum, *Sauv.* sp. 22.
Hemiplegia saturnina, *Sauv.* sp. 14.

This kind of palsy arises most frequently from lead taken into the body, and is a consequence of the colica pictonum, under which it is more particularly treated.

TREMOR, or Trembling. 270

Tremor, *Sauv.* gen. 129. *Lin.* 139. *Vog.* 184. *Sag.* 236.

This by Dr Cullen is reckoned to be always symptomatic either of palsy, asthenia, or convulsions; and therefore need not be treated of by itself.

Order II. ADYNAMIÆ. 271

Adynamiæ, *Vog.* Class VI.
Defectivi, *Lin.* Class VI. Order I.
Leipopsychiæ, *Sauv.* Class VI. Order IV. *Sag.* Class IX. Order IV.

Genus XLIV. SYNCOPE. 27

Fainting.

Syncope, *Sauv.* gen. 174. *Sag.* 94. *Vog.* 274. *Sag.* 280. *Junck.* 119.
Leipothymia, *Sauv.* gen. 173. *Lin.* 93. *Vog.* 273. *Sag.* 279.
Asphyxia, *Sauv.* gen. 175. *Lin.* 95. *Vog.* 275. *Sag.* 281.
Virium lapsus et animi deliquia, *Hoffm.* III. 267.

Sp. I. The *Cardiac* Syncope. 27

Syncope plethorica, *Sauv.* sp. 5. *Senac.* Tr. de Cœur, p. 540.
Syncope à cardiogmo, *Sauv.* sp. 7. *Senac.* de Cœur, 414. *Morgagn.* de Sed. XXV. 2. 3. 10.
Syncope à polypo, *Sauv.* sp. 8. *Senac.* p. 471.
Syncope ab hydrochardia, *Sauv.* sp. 12. *Senac.* 533. *Schreiber* Almag. L. III. § 196.
Syncope *Lanzoni*, *Sauv.* sp. 18. *Lanzon.* Op. II. p. 462.
Asphyxia Valsalviana, *Sauv.* sp. 13.

Sp. II. *Occasional* Syncope. 2

Leipothymia à pathemate, *Sauv.* sp. 1. *Senac.* p. 544.
Syncope pathetica, *Sauv.* sp. 21.
Asphyxia à pathemate, *Sauv.* sp. 7.
Syncope ab antipathia, *Sauv.* sp. 9. *Senac.* p. 544.
Syncope à veneno, *Sauv.* sp. 10. *Senac.* p. 546.
Syncope ab apostematis, *Sauv.* sp. 11. *Senac.* p. 544.
Syncope à sphacelo, *Sauv.* sp. 14. *Senac.* p. 553.
Syncope ab inanitione, *Sauv.* sp. 1. *Senac.* p. 536.
Syncope à phlebotomia, *Sauv.* sp. 4.
Syncope à dolore, *Sauv.* sp. 2. *Senac.* sp. 583.

Asphyxia

Adynamiæ.

Asphyxia traumatica, *Sauv.* sp. 14.
Asphyxia neophytorum, *Sauv.* sp. 17.

Description. A syncope begins with a remarkable anxiety about the heart; after which follows a sudden extinction, as it were, not only of the animal powers and actions, but also of the vital powers, so that the patients are deprived of pulse, sense, and motion, all at once. In those cases which physicians have distinguished by the name of *leipothymia*, the patient does not entirely lose his senses, but turns cold and pale; and the pulse continues to beat, though weakly; the heart also seems to tremble rather than beat; and the respiration is just perceptible. But in the true syncope or full asphyxia, not the smallest sign of life can be perceived; the face has a death-like paleness, the extremities are cold, the eyes shut, or at least troubled; the mouth sometimes shut, and sometimes gaping wide open; the limbs flaccid, and the strength quite gone; as soon as they begin to recover, they fetch deep and heavy sighs.

Causes, &c. Fainting is occasioned most commonly by profuse evacuations, especially of blood; but it may happen also from violent passions of the mind, from surfeits, excessive pain, &c. People of delicate constitutions are very subject to it from slight causes; and sometimes it will arise from affections of the heart and large vessels not easy to be understood. Fainting is also a symptom of many disorders, especially of that fatal one called a *polypus of the heart*, of the plague, and many putrid diseases.

Prognosis. When fainting happens in the beginning of any acute distemper, it is by no means a good omen; but when it takes place in the increase or at the height of the disease, the danger is somewhat less; but in general, when fainting comes on without any evident cause, it is to be dreaded. In violent hæmorrhagies it is favourable; as the bleeding vessels thus have time to contract and recover themselves, and by this means the patient may escape.

Cure. When persons of a full habit faint through excess of passion, they ought to be blooded without delay, and should drink vinegar or lemon juice diluted with water; and, after the bowels are emptied by a clyster, take a paregoric draught, and go to bed.

The passion of anger, in a peculiar manner, affects the biliary secretion, causes an oppression at the stomach, with nausea and retching to vomit, and a bitter taste in the mouth, with giddiness: these symptoms seem to indicate an emetic; which, however, in these cases must be carefully avoided, as it might endanger the patient, by bringing on an inflammation of the stomach.

The general effects of a sudden fright have been mentioned on a former occasion. When these are so violent as to require medical aid, our first endeavours must be to take off the spasmodic constriction, and restore freedom to the circulation; by bleeding, if the habit be at all inclined to fulness; and by giving a mixture, with equal parts of the vinum antimoniale and tinctura opii camphorata, in some agreeable vehicle, which will bring on sleep and encourage perspiration. It was formerly mentioned, that convulsions, or even an epilepsy, may be brought on by frights; which should make people cautious of playing foolish tricks in this way.

Dyspepsia.

When a surfeit, or any species of saburra, occasions leipothymia, an emetic is the immediate remedy, as soon as the patient, by the help of acrid stimulants, shall be so far roused as to be able to swallow one: in these cases, tickling the fauces with a feather dipt in spirit of hartshorn, will be proper, not only to rouse the patient, but also to bring on vomiting.

A syncope is most commonly brought on by profuse discharges or evacuations, either of the blood or of the secreted humours.

In order to revive the patients, they ought to be laid along in a horizontal posture, in an airy place; the legs, thighs, and arms, are to be rubbed with hot flannels; very strong vinegar, aromatic vinegar, or salt of hartshorn, or volatile alkaline spirit, are to be held to the nostrils, and rubbed into them; or, being properly diluted, poured down the throat; cold water is to be sprinkled on the face and neck; and when by these means the patient shall be sufficiently revived, wine boiled up with some grateful aromatic, is to be given in the proper quantity.

In the fainting consequent upon profuse uterine hæmorrhagies, it will be a safer practice to abstain from all heating and stimulant things; as life, in these cases, is preserved by the coagulation of the blood in the extremities of the open vessels; which might be prevented by the pouring in hot wine or volatile alkaline spirits.

When a syncope is the consequence of the too violent operation of either an emetic or cathartic, the tinctura thebaica, mixed with spiced wine, is the most efficacious remedy; but the opiate must be given gradually, and in very small doses.

A syncope, or even asphyxia, wherein the patient shall lie for several hours, is frequent in hysteric constitutions; and during the fit requires fetid antispasmodics, together with acrid stimulants: to prevent returns, nothing answers better than the cinchona joined with chalybeates.

Genus XLV. DYSPEPSIA. 275

Depraved Digestion.

Dyspepsia, *Vog.* 277.
Apepsia, *Vog.* 276.
Diaphora, *Vog.* 278.
Anorexia, *Sauv.* gen. 162. *Lin.* 116. *Sag.* gen. 286.
Cardialgia, *Sauv.* gen. 202. *Lin.* 48. *Vog.* 157. *Sag.* gen. 160.
Gastrodynia, *Sauv.* gen. 203. *Sag.* gen. 161.
Soda, *Lin.* 47. *Vog.* 161.
Nausea, *Sauv.* gen. 250. *Lin.* 182. *Vog.* 159. *Sag.* gen. 185.
Vomitus, *Sauv.* gen. 251. *Lin.* 183. *Vog.* 214. *Sag.* gen. 186.
Flatulentia, *Sauv.* gen. 272. *Lin.* 165. *Vog.* 127. *Sag.* gen. 207.

The idiopathic species are,

Anorexia pituitosa, *Sauv.* sp. 2.
Anorexia à saburra, *Sauv.* sp. 9.
Anorexia exhaustorum, *Sauv.* sp. 8.

Adynamiæ.

Anorexia paralytica, *Sauv.* sp. 1.
Nausea ex cacochylia, *Sauv.* sp. 11.
Vomitus pituitosus, *Sauv.* sp. 26.
Vomitus ruminatio, *Sauv.* sp. 6.
Vomitus à saburra, *Sauv.* sp. 2.
Vomitus à crapula, *Sauv.* sp. 1.
Vomitus lacteus, *Sauv.* sp. 3.
Flatulentia infantilis, *Sauv.* sp. 5.
Flatulentia acida, *Sauv.* sp. 1.
Flatulentia nidrosa, *Sauv.* sp. 2.
Cardialgia bradypepta, *Sauv.* sp. 9.
Cardialgia à saburra, *Sauv.* sp. 2.
Cardialgia lactantium, *Sauv.* sp. 11.
Cardialgia flatulenta, *Sauv.* sp. 3.
Cardialgia paralytica, *Sauv.* sp. 7.
Gastrodynia saburralis, *Sauv.* sp. 1.
Gastrodynia flatulenta, *Sauv.* sp. 2.
Gastrodynia periodynia, *Sauv.* sp. 7.
Gastrodynia astringens, *Sauv.* sp. 9.
Gastrodynia atterens, *Sauv.* sp. 10.
Gastrodynia à frigore, *Sauv.* sp. 18.

Besides these there are a great number of symptomatic species.

Description. It is by no means easy to define exactly the distemper called *dyspepsia*, when considered as an original disease, as there are very few maladies which some way or other do not show themselves by an affection of the stomach; and much more difficult still must it be to enumerate all its symptoms. The most remarkable, however, and the most common, are the following: Want of appetite; distention of the stomach when no food has been taken for some time before; slight dejection of spirits; a gradual decay of the muscular strength; languor, and aversion from motion; the food which is taken without appetite is not well digested; the stomach and intestines are much distended with flatus, whence the patients are tormented with spasms, gripes, and sickness: frequently a limpid water, having an acid or putrid taste, is brought up; sometimes the food itself is thrown up by mouthfuls; and sometimes, though rarely, the same is swallowed again, after the manner of ruminating animals. While matters are in this situation, the heart sometimes palpitates, and the breath is quick, and drawn with difficulty; the head aches and is giddy; and sometimes both these symptoms are continual, and very violent, insomuch that the patient is not only tormented with pain, but staggers as if he was drunk. From the too great acescency or putrefaction of the aliment a cardialgia or heartburn comes on; and in this situation a spontaneous diarrhœa sometimes carries off the disease; but in other cases there is an obstinate costiveness, attended with colic-pains. Frequently the pulse is quick, sometimes slow, but always weak: the circulation is so languid, that the blood can scarce reach the extreme vessels, or at last stagnates in them, so that the face becomes livid, swelled and has an unusual appearance: and at the same time that the circulation and nervous power are in this languid state, the perspiration becomes less copious; the skin becomes dry and corrugated; the natural heat, especially of the extremities, is much diminished; the tongue is white; and an universal laxity takes place, insomuch that the uvula and velum pendulum palati are sometimes enlarged to such a degree as to become extremely troublesome. The patient is either deprived of rest, or wakes suddenly out of his sleep, and is disturbed by frightful dreams; at the same time that the mind seems to be affected as well as the body, and he becomes peevish, fretful, and incapable of paying attention to any thing as usual. At last hectic symptoms come on, and the whole frame becomes so irritable, that the slightest cause excites an universal tremor, and sometimes violent vomiting and diarrhœa. Sometimes the salivary glands are so relaxed, that a salivation comes on as if excited by mercury; the serum is poured out into the cavity of the abdomen and cellular substance of the whole body, and the patient becomes affected with anasarca or ascites.

Dyspepsia.

Causes, &c. The causes of dyspepsia may be any thing which debilitates the system in general, but in a particular manner affects the stomach. Such are, opium taken in immoderate quantities, which hurts by its sedative and relaxing powers; spirituous liquors drunk to excess; tobacco, tea, coffee, or any warm relaxing liquor, taken in too great quantity; acid, unripe fruits; vomits or purges too frequently taken; an indolent sedentary life, &c. &c. All these act chiefly upon people of a weak and delicate habit; for the robust and hardy seldom labour under a dyspepsia, or at most a very slight one.

Prognosis. When a dyspepsia first occurs, it is frequently removed without great difficulty; when it is symptomatic, we must endeavour to cure the primary disease; and without this we cannot expect a complete removal of the affection; but when it frequently returns, with symptoms of great debility, hectic fever, or dropsy, we have great reason to dread the event.

Cure. A radical cure of dyspepsia is only to be expected by removing from the stomach and system that debility on which the disease depends. On this ground, the objects chiefly to be aimed at in the cure are, 1st, The avoiding whatever will tend to diminish the vigour of the stomach; 2d, The employing such remedies as have influence in increasing that vigour; and, in the third place, The obviating urgent symptoms, particularly those which tend to increase and support the affection. Of the avoiding causes, which tend to diminish the vigour of the stomach, after what has already been said of the causes inducing the disease, it is unnecessary to make any farther observations: and indeed every dyspeptic patient will be taught by experience what is to be done with this intention. The medicines chiefly employed with the view of increasing vigour are those of the tonic kind: but, previous to their use, it will be necessary to evacuate the contents of the alimentary canal by vomits or purgatives. If there be a tendency to putrescency, antiseptics must then be exhibited; but more frequently there is a prevailing acidity, which creates an intolerable heart-burn. To palliate this symptom, magnesia alba may be given; which is much preferable to the common testaceous powders, as being purgative when dissolved in an acid, while the others are rather astringent. In the third volume of the Medical Observations, we have an account of two cases of dyspepsia attended with a very uncommon degree of cardialgia, in which magnesia was so successful, that we can hardly doubt of its efficacy in slighter degrees of the disorder.

But

Ady mixe.

But although acidity may often be successfully obviated in this manner, yet the best way of counteracting this symptom, as well as of obviating costiveness, flatulence, and a variety of others, is by restoring the tone of the stomach in particular, and indeed of the system in general. With this intention, recourse is had to a variety of tonics both from the mineral and vegetable kingdom; particularly chalybeates in different forms, gentian, colombo, and the like; but of all the tonics which can be employed in this affection, none are attended with greater benefit than exercise and cold bathing; and the proper and prudent employment of these is no less effectual in removing the disease, than in preventing the return of it after it is once removed.

6 Genus XLVI. HYPOCHONDRIASIS.

Hypochondriac Affection.

Hypochondriasis, *Sauv.* gen. 220. *Lin.* 76. *Vog.* 218. *Sag.* 332.
Morbus hypochondriacus, *Boerh.* 1098.
Malum hypochondriacum, *Hoffm.* III. 65. *Junck.* 36.

Although some of the nosological writers, particularly Sauvages, have considered this genus as consisting of different species, Dr Cullen is of opinion, that there is only one idiopathic species, the *hypochondriasis melancholica*. He considers not only the hypochondriasis hysterica, phthisica, and asthmatica, but also the biliosa, sanguinea, and pituitosa, as being only symptomatic; but he views the true melancholic hypochondriasis as being a proper idiopathic disease, perfectly distinct from hysteria, with which it has often been confounded.

Description. The symptoms of hypochondriasis are, stretching, pressing, griping, and tormenting pains under the ribs, and chiefly in the left side; which sometimes are exasperated, and become pungent, burning, or lancinating. Frequently there is an inflation of the left hypochondrium, which sometimes becomes stationary, and by Hippocrates was taken for a symptom of an enlarged spleen. When these symptoms take place in the right hypochondrium, they are commonly attended with colic pains, uncertain flying heats, especially in the head, with a transient redness of the face, and very frequently an œdematous swelling of the feet succeeds. To these are superadded almost all the affections of the stomach occurring in dyspepsia, besides a variety of other symptoms, such as palpitations, sleepless nights, and the like. But besides these, there occurs also a particular depression of spirit and apprehension of danger, which may be considered as one of the great characteristic symptoms of the disease.

Causes, &c. The general causes of the hypochondriac affection are said to be a plethora, and preternatural thickness of the blood; suppressions of customary evacuations; high and full diet, together with a sparing quantity of drink; an hereditary disposition; indolence; atony of the intestines; violent passions of the mind, &c.

Prognosis. The hypochondriac affection, when left to itself, is more troublesome than dangerous; but, if improperly treated, it may bring on various diseases of a more fatal tendency, such as the melancholy, bloody urine and nephritis, jaundice, vertigo, palsy, apoplexy, &c. Chlorosis.

Cure. This is to be attempted by such medicines as counteract occasional causes, and obviate urgent symptoms, which may be all comprehended under bleeding, gentle evacuants, chalybeates, the cinchona, and exercise, especially riding on horseback, which in this disease is greatly preferable to any other. When the circumstances of the patient can afford it, a voyage to Spain, Portugal, or some of the warmer countries in Europe, will be of great service.

Genus XLVII. CHLOROSIS. 277

Green Sickness.

Chlorosis, *Sauv.* gen. 309. *Lin.* 222. *Vog.* 305. *Sag.* gen. 135. *Boerh.* 1285. *Hoffm.* iii. 311. *Junck.* 86.

Of this genus also Dr Cullen thinks there is but one idiopathic species: viz. what some distinguish by the title of *chlorosis virginea*, others of *chlorosis amatoria*.

Description. This disease usually attacks girls a little after the time of puberty, and first shows itself by symptoms of dyspepsia. But a distinguishing symptom is, that the appetite is entirely vitiated, and the patient will eat lime, chalk, ashes, salt, &c. very greedily; while at the same time there is not only a total inappetence to proper food, but it will even excite nausea and vomiting. In the beginning of the disease, the urine is pale, and afterwards turbid; the face becomes pale, and then assumes a greenish colour; sometimes it becomes livid or yellow: the eyes are sunk, and have a livid circle round them; the lips lose their fine red colour; the pulse is quick, weak, and low, though the heat is little short of a fever, but the veins are scarcely filled; the feet are frequently cold, swell at night, and the whole body seems covered with a soft swelling; the breathing is difficult: nor is the mind free from affection more than the body; it becomes irritated by the slightest causes; and sometimes the patients love solitude, become sad and thoughtful. There is a retention of the menses throughout the whole course of the disorder; and at last all the bad symptoms increasing, a leucophlegmasia, anasarca, atrophy, and death succeed.

Causes. The cause of chlorosis is thought to be an atony of the muscular fibres of the alimentary canal, especially of the stomach, joined with a similar atony of the perspiratory vessels over the whole surface of the body, and the whole depending on an atony of those small arteries which pour out the menstrual blood. This atony may be occasioned by the same causes which bring on dyspepsia and hypochondriasis, but very frequently arises from love and other passions of the mind.

Prognosis. The chlorosis in all cases is tedious, though it does not generally prove fatal; but we can never promise a certain cure unless the menses make their appearance.

Cure. The remedies here in general are the same as in the dyspepsia and hypochondriasis; only in the chlorosis stronger purgatives may be made use of: those which stimulate the rectum are useful by stimulating

Spasmi. lating also the vessels of the uterus; and for this reason indulgence in venery has sometimes been said to produce a cure, particularly with love-sick maids. The cold bath is also extremely proper.

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ORDER III. SPASMI.

Spasmi, *Sauv.* Class IV. *Vog.* Class V. *Sag.* Class VIII.
Motorii, *Lin.* Class VII.
Morbi spasmodici et convulsivi, *Hoffm.* III. 9.
Spasmi et convulsiones, *Junck.* 45, 54.
Epilepsia, *Boerh.* 1071, 1088.

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GENUS XLVIII. TETANUS.

Tetanus, *Sauv.* gen. 122. *Lin.* 127. *Vog.* 180. *Sag.* gen. 228.
Catochus, *Sauv.* gen. 123. *Lin.* 128. *Vog.* 183. *Sag.* gen. 229.
Opisthotonos, *Vog.* 181.
Episthotonos, *Vog.* 182.

On this distemper Dr Lionel Chalmers has published a dissertation in the first volume of the Medical Observations, which being superior to any thing that has appeared in other medical writers on the subject, we shall here lay before the reader.

"Of all the diseases to which man is subject, none deserves more to be considered than the opisthotonos and tetanus, either with regard to the variety of painful symptoms which almost without intermission distract the sick, or the danger of the diseases themselves, from which few recover, in comparison of the number they attack. In both, the vital actions are very imperfectly performed, most of those which are called *natural* being as it were suspended at once; and so far is the patient from being able to execute any voluntary motion, that the whole machine undergoes the most excruciating distortions, from the violent and unnatural contractions of the muscles. Happy it is for the inhabitants of the more temperate climates, that such diseases appear rarely among them; but in those countries which lie in the more southern and warmer latitudes, they are endemic, especially to negro slaves. In South Carolina, they show themselves at all seasons, but not so often in winter, more frequently in spring and autumn; and are most common in the summer, when people work abroad and are alternately exposed to the scorching heat of the sun and heavy showers, which often happen suddenly, and greatly alter the temperature of the air. Others are seized with the opisthotonos after sleeping without doors, that they may enjoy the deceitful refreshment of the cool night-air, when the weather is warm: one youth chose to cut off his hair and shave his head on a warm day in March, and went to bed without a cap, but the weather changed, and became cold in the night, and he was found rigid with tetanus next morning.

"These diseases so rarely appear as originals in Europe, that a good history of them cannot be expected from the physicians who practise in that part of the world; nor has any thing like a full description been given of them by any ancient or modern author which I have seen. Hippocrates indeed takes notice of them in many places, and seems to regard them only as consequences of other diseases, or of wounds or ulcers of the nervous or tendinous parts; of which symptomatic kind of opisthotonos he gives three remarkable cases in *lib.* v. § vii. *de Morb. vulg.* and repeats them in another place: but the few symptoms he recounts do not show themselves with us. Galen, Cœlius Aurelianus, Aretæus, &c. seem only to have copied Hippocrates, with the addition of some supposititious symptoms, which really do not appear; and the little that Bontius says of it is very faulty. Tetanus.

"Among the numerous class of spasmodic diseases, there are three which distinguish themselves in a very particular manner, on which the names of *emprosthotonos*, *opisthotonos*, and *tetanus*, have been justly enough bestowed, as being expressive of the posture into which they throw and confine the patient. When therefore those muscles which bend the head, neck, and body forwards, suffer such involuntary, violent, and continued contractions, as to fix the chin to the breast, incurvate the spine and body, and retain the sick in this painful and prone posture, the disease is called *emprosthotonos*. When the posterior muscles are similarly affected, so that the head is drawn towards the spine, and the spine itself is recurvated, it has then the name of *opisthotonos*; although in fact, in this, all those mucles which act in deglutition, bend the head forwards, or turn it to either side, are equally contracted with those which raise the head and spine. The *tetanus* differs from, or rather is compounded of, both the others; for in this the patient is found rigid and inflexible, being as it were braced between the opposite contractions of the anterior and posterior muscles; yet even here the head is much retracted.

"I never saw the *emprosthotonos*; and shall only speak of the *opisthotonos* and *tetanus*, the first being by far the most common, and in the last stage of which the tetanus frequently intervenes. Let it be observed, that the following description by no means respects such symptomatic contractions as often happen immediately before death, both in acute and chronic diseases; neither will it agree with that spurious *opisthotonos* or *tetanus* which appear sometimes in the first and second stages of quotidian intermittents in this country, however they may emulate the true diseases in some of their symptoms.

"Stad. I. The *opisthotonos*, contrary to what Bontius asserts, often comes on gradually and by slight approaches, the patient complaining rather of an uneasy stiffness in the back part of the neck and about the shoulders, than of any acute pain, with some degree of a general lassitude. These increase, and become so troublesome when he attempts to turn his head, or to bend it forward, as to oblige him to walk very erect; for he can by no means look downward, nor to either side, without turning his whole body. He cannot open his jaws without pain; and has some difficulty in swallowing, which discourages him from attempting to eat. At times he feels a sudden and painful traction under the *cartilago ensiformis*, which strikes through to the back, and instantly increases the rigidity about the neck and shoulders, draws the head backward a little, and shuts the jaws closer. The pain under the *sternum* returns more frequently and with greater violence;

lence; and the other contractions become so strong, that the head from this time continues much retracted, and he now refuses nourishment, as swallowing is attended with great pain, and occasions a return of the spasm; which extends along the spine quite to the lower extremities, so that they will no longer support him, and he is under the necessity of going to bed.

"In this manner passes over the first stage of the *opisthotonos*, which sometimes takes up three or four days; the patient, as well as those about him, mistaking the first appearances of it for that rheumatic complaint, which is commonly called a *crick in the neck;* but it sometimes forms itself much quicker, and invades the unfortunate person with the whole train of its mischievous symptoms in a few hours: in which case, the danger may truly be estimated from the violence of the first attack; for such generally die in 24, 36, or 48 hours, and very rarely survive the third day. But when it is less acute, few are lost after the ninth or eleventh: which number of days it would not be possible for them to complete, unless the violence of the disease was in a good measure subdued; although I had one who recovered, after having been subject to its tyrannical attacks daily for six weeks. In this stage the pulse is slow, and very hard, and the belly is bound; blood taken away seems not to be altered from the natural state, so that no indication can be deduced therefrom, and it only varies with regard to laxity or compaction, according to the age of the person and season of the year.

"Stad. II. The spasm under the sternum (which is the pathognomonic symptom of this disease) becomes more violent, returning every 10 or 15 minutes; and never fails to be instantly succeeded by a stronger retraction of the head, with great rigidity and pain all round the neck, and along the spine to the lower extremities, which are suddenly put to the stretch. The countenance is very pale and contracted; the jaws are that moment snapped together, and cannot afterwards be opened so wide as to receive the end of one's little finger; an attempt to do which, by way of experiment, almost constantly hurries on the spasm. The mastoid, coraco-hyoid and sterno-hyoid muscles, as well as all the others concerned in deglutition, and the deltoid and pectorals, are most violently contracted, so that the shoulders are strongly raised forward, and the arms are stretched out or drawn across the body; but the wrists and fingers seem not to be affected.

"Such is the condition of the patient in the time of the spasm, which ceases in a few seconds: after which the shoulders and arms recline, and the inferior extremities relax; yet not so entirely, but that such a degree of rigidity for the most part remains as will not permit them to bend when this is attempted by another person; for as to the sick himself, he cannot at all move them. The muscles on the sides and forepart of the neck continue still contracted, although not so strongly; but their action is overcome by the number and strength of the posterior ones; so that the retraction of the head constantly remains. The patient breathes quick for some minutes, as if he had been excessively exercised; and the pulse is small, fluttering, and irregular, but both become more calm and slow. The face is sometimes pale in the intervals, but oftener flushed; and the whole countenance expresses strong appearances of the most melancholy distress, as well because of the dread he has of a return of the spasm, which he is sure will soon happen, as from the pain he suffers by the present contractions, and the more general and severe ones which he has so lately sustained. The tongue is stiff and torpid; but so far as it can be seen, is not foul. The belly is always bound, and cannot easily be loosened. In drinking, the liquid passes with great difficulty to the stomach, even in the smallest quantity; and if the spasm should seize him at that time, which an attempt to swallow for the most part occasions, the liquor returns through the nose with some force. The patients desire to lie still as much as possible; and avoid drinking, speaking, or being moved, either of which are apt to occasion a return of the spasm.

"Stad. III. In this last stage, the patient is reduced to the most calamitous and distressful circumstances: for he is on a continual rack, according to the most literal meaning of that word; the spasm returning oftener than once in a minute, is much more violent, and holds him longer, so that he has scarcely any remission. The anterior muscles of the whole body now suffer equal contractions with the posterior; but the last overcome the force of the others, so that the spine is strongly recurvated, and forms a hollow arch with the bed, and he rests on the back part of the head and the heels. The belly is flat, and is drawn inward; and the muscles are so rigidly contracted, that they will not give way to pressure, and do not seem in the least to yield to the descent of the diaphragm in inspiration; the several muscles about the neck, sides, and abdomen, being plainly distinguishable from each other. Although the lower extremities are always rigid in this state, yet are they so suddenly and violently distended in the time of the spasms, that were it not for the standers by, the patient would be projected feet foremost off the bed; while others again are as it were pushed upwards with such a spring, that the head is struck with great force against whatever happens to be in the way, the thighs and legs being in this case no less rigid than the other parts. The tongue is spasmodically darted out, and is often miserably torn, as the teeth are that moment snapped together; so that it is necessary to prevent this by keeping the handle of a spoon, wrapped round with soft rags, between the teeth, when this can be done. At the time that the tongue is thus thrust out, the muscular flesh, which lies between the arch of the lower jaw and head of the trachea, seems to be drawn upwards within the throat. The countenance is very much contracted, and he is in a foam of sweat, the heat being very great; and the pulse between the spasms is exceedingly quick, small, and irregular, although the heart throbs so strongly, that its motions may be plainly seen, and a palpitating subsultory kind of undulation may not only be felt, but perceived all over the epigastric region. The eyes are watery and languid, and a pale or bloody froth bubbles out from between the lips. The jaws are for the most part locked fast, so that it is impossible to give drink or nourishment, nor could he swallow any thing that was put into his mouth. In this state patients are commonly delirious: and as they cannot subsist many hours under so great a suspension of the vital and natural functions, a mortal anxiety ensues and releases

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releases them; oftener a continued and severe spasm finishes the tragedy, when it was before almost at an end: but most frequently a general convulsion puts a period to their sufferings; and whichever way this happens, they for the most part relax just before death.

"In the *tetanus*, the general symptoms are nearly the same as in the opisthotonos, except that from the first attack, the lateral, abdominal, and other anterior muscles, are equally contracted with the posterior ones; and the arms become rigid as well as the lower extremities. The abdomen is always flat and rigid as in the last stage of the opisthotonos, and its contents seem to be thrust up into the thorax, which at the same time appears to be much dilated. There are here also some intervals between the spasms, in the time of which the cheeks are drawn towards the ears, so that all the teeth may be seen as in the spasmus cynicus. Deglutition is more free in this than in the other disease; yet so far is the sick from being equally balanced between the contractions of the opposite muscles, that the head is retracted and the spine is recurvated, although not quite so much as in the opisthotonos. And the spasm, which commences under the sternum, is likewise common to the tetanus, which terminates as the other, and on the same fatal days. But whoever recovers from either, labours long under a general atonia; and they cannot for some months raise themselves from a supine or recumbent posture without pain, nor without help for some time."

Prognosis and Cure. There has never been any thing like a crisis observed in these frightful cases, or favourable termination from the mere efforts of nature; and therefore all the physician's dependence must be upon art. As in cases of tetanic affections, the disease often arises from some particular irritation, the removal of this must necessarily be an important object in the cure: But where it cannot be removed, benefit may often be obtained by the prevention of its influence being communicated to the brain. When, however, that influence is communicated to the brain, a cure is to be expected only by diminishing and obviating it. This is principally brought about by the use either of those means which have a general tendency to diminish action, or of those which induce a different state of action. On these grounds the operation of those remedies which are employed with greatest success in this affection, may, we apprehend, be explained. Fortunately it has been found, that opium is capable of giving some relief, if administered in proper time, and if the disease happens not to be in the most violent degree: the warm bath must also be brought in aid; and the patients should lie horizontally in the bath, and while in it have the whole body extremely well rubbed: when taken out, they are not to be dried, but immediately be put to bed wrapt in the softest blankets; and while they remain there, the belly ought either to be stuped, or two or three bladders filled with warm water kept constantly lying on it. The bowels at the same time must, if possible, be kept open, by solutions of manna and *sal polychrest*, or some other purging salt, mixed with *oleum ricini;* or if that should not be at hand, with oil of sweet almonds and a little tincture of senna. The opiates are to be given in large and frequently repeated doses; such as a grain of the *extractum thebaicum*, or 20 drops of the tincture, every second or third hour; and it will be safest not to trust to the thebaic tincture which is kept ready prepared in the shops, but to order the necessary dose of solid opium, and either give it in pills or dissolve it in some convenient liquid. If swallowing should be difficult, or the jaws closed up, the opium must be given in clysters; for during the whole course of the disease it will be of service to order emollient clysters to be injected from time to time, since these will answer not only as a relaxing fomentation, but also contribute to keep the intestinal canal perfectly free.

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When the patients recover, they continue for a long time very relaxed and weak; and no wonder, since it is the nature of all spasmodic affections to leave behind them extreme weakness and relaxation of the muscular fibres. In order to perfect the recovery, a course of the cinchona and the Peruvian balsam is to be tried; and the spine may be rubbed with spirituous liniments, or with a mixture of rum and Barbadoes tar: but those and all other stimulating things, either internally or externally, during the violence of the spasms, must, in the opinion of some practitioners, be omitted, since all of them as well as blisters have been alleged to exasperate the disease.

This, in general, is the plan of treatment recommended by Dr Chalmers.

The same dreadful disorders frequently attack young children in the warm climates. Dr Hillary tells us, that they will there arise from the same causes which usually produce convulsions with children in Britain, viz. from a retention of the meconium or first excrement after birth; or from a glutinous matter which is too often found in the intestines of young children soon after the other is discharged; or from a cheesy matter from the coagulation of the milk by an acid in the stomach; or from hard excrements; or from something taken in by the mouth which is over acrid, or too hard to digest, which irritates their tender bowels, and so produces startings and convulsive spasms, with all the other symptoms which precede and accompany convulsions in young children in Britain. And this shows how much more readily and easily the nerves are affected and irritated in that warm climate, and the *tetanus* produced from a much less cause there, than it is in Britain, where it is but seldom seen. But these causes not being timely removed, their acrimony is increased, partly by the heat of the climate, and partly by the fever which they produce, which still renders them more acrid, and so increases the irritation of their bowels, that it first brings on startings, then convulsive spasms, and regular convulsion fits; which, if not soon removed, usually end in a perfect *tetanus*, and the disease is but seldom cured in such young children when it arrives at that state: for when the child lies in this miserable, rigid, immoveable condition, upon moving its hands or feet in the most gentle manner, or softly touching any part of its body, or giving it the least motion, even feeling its pulse in the most tender manner, or the least noise, or even touching its clothes, will bring on the convulsive spasms, and cause it to be strongly convulsed backwards or drawn into a rigid straight line, strongly extended and immoveable like a statue, and will so remain immoveable out of either of those postures for a considerable time, a minute or two; and when the disease is arrived at this degree, Dr Hillary thinks

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thinks it is never cured. But if the physician be called in time, before the *tetanus* has come on (which is too seldom the case there), though he finds strong convulsive spasms have seized the child, or that it has had a convulsive fit or two, it may most commonly be relieved, the coming of the *tetanus* be prevented, and the life of the babe saved, as Dr Hillary has more than once seen, by removing and carrying off the irritating cause which stimulates their tender bowels, by such gentle evacuations as are suitable to their age; and then quieting and composing the irritation of their nerves by proper anodynes, and correcting the remaining acrimony of the nutritious juices in the *primæ viæ*.

To answer these intentions, the following method, with variations *pro re nata et pro ratione ætatis*, as the cause is different, has been found to answer the desired effect the best: ℞ *Seri lactis* ℥ij. *Sapon. Venet.* ℈j. *Mannæ Calab.* ʒij. *vel* iij. *Ol. amygd. dul.* ʒss. *Ol. fœniculi dul. gut.* ij. *Bals. Peruv. gut.* v. *Misc. Fi enema quam primum injiciendum.*

And if the symptoms of the approaching *tetanus* will permit, he gives something of the following nature to assist the operation of the clyster, and to carry off the acrimony the sooner: ℞ *Aq. sem. fœniculi* ℥iij. *Magnes. albæ* ʒss. *Ocul. cancr. præp.* ʒj. *Syr. è cichor. cum rheo, Rosar. solut. ana* ʒiij. *Misce.* Or, ℞ *Aq. sem. fœniculi* ʒiij. *Sapon. amygdal.* ʒss. *Magnes. albæ* ʒss. *Syr. è cichor. cum rheo. Mannæ opt. ana* ℥ij. *Ol. amygd. dul.* ʒiij. *Misce: Exhibe cochl. parv. vel duo pro ratione ætatis, omni semihora, vel omni hora, donec respond. alvus.*

Two or three stools being obtained by these, the following is exhibited in order to abate the convulsive twitchings, and prevent the *tetanus* from coming on: ℞ *Aq. sem. fœniculi* ℥iij. *Magnes. albæ* ʒss. *Ocul. cancr. præp.* ʒj. *Moschi orient. gr.* iij. *Spir. C. C. gut.* xv. *Syr. è mecon.* ʒss. *Misce: Exhibe cochl. parv.* (a child's spoonful) *ter quaterve de die, vel sæpius, urgent. convuls. vel spasm.*

But if the symptoms show that the *tetanus* is more immediately coming on, so that we have no time to wait till the operation of the clyster and opening laxative be over, something of the following nature must be immediately given; or the *tetanus* will come on, and most probably prove fatal to such tender babes. ℞ *Aq. fœnicul.* ʒiiij. *Moschi orient. gr.* j. *Tinct. thebaic. gut.* iiij. *Syr. è mecon.* ʒij. *Misce pro duobus dos. de quibus exhibe unam quam primum, et alteram si convul. spasm. redeunt.*

This, Dr Hillary observes, may be thought a bold attempt, to give *tinct. thebaica* to such a tender young infant: but it is to be considered that the little patient will certainly die if the *tetanus* seize it, and that it will come on if this do not prevent it: and he has known a bold ignorant old midwife give four or five drops of that tincture to a very young infant without any prejudice more than its dosing three or four hours, though not in this case, but in one much less violent.

The clyster may be given at the same time, and the opening laxative not long after it; though it may retard the operation of that for some time, yet it operates soon after, and gives relief; after which the other medicines, and fomenting the body and anointing it as before, may be used, if the physician finds it necessary; also a little of the laxative mixture may be given once or twice a-day, if the above julep does not answer the intention of keeping the child's body open for a few days afterwards, which in this case is generally found necessary to be observed.

These methods and medicines may be varied according to circumstances. For neither the same method nor the same medicines will answer in all cases, though the disease be the same; but they must be changed as the causes differ, or the constitution of the sick, or the time of the disease, or as some other circumstances may require: which is a thing of great importance, not only in this, but in the cure of most other diseases.

When proper medicines are thus timely and judiciously given in this case, they seldom fail to carry off the irritating cause, quiet and ease the nerves, remove the convulsions and spasms: and consequently prevent the tetanus from coming on, and the death of the patient. But if calling in the physician be deferred till the tetanus has already strongly seized the child, as is too often the case here, neither warm bathing, fomenting, nor any other methods or medicines whatever, will remove it or its causes, nor save the life of the little tender patient.

Dr Chalmers gives an account of his having cured one child seized with a *tetanus*, by purging with an infusion of rhubarb: to which a few grains of musk, and a little *ol. tartar. per deliq.* were added, together with the warm bath, and the frequent injection of clysters made with an infusion of chamomile flowers, to each of which was added a small portion of Castile soap. It is much to be regretted, however, that in those cases where the assistance of the medical art is most wanted, it most generally fails. We have been assured by a gentleman who practised for some time in the warm parts of America, that out of 30 cases of the tetanus he had seen, not one of the patients recovered, though he had given opium to the quantity of 20 grains thrice a-day; and others, he was assured, had taken 30 grains thrice a-day. In the beginning of the disease, the medicine produced a violent headach; but towards the end, it had no manner of effect whatever. In two patients, the disease came on from the slightest causes imaginable. The one accidentally fell in attempting to avoid a loaded cart, and put the heel of his shoe upon one of his thumbs in rising; the other, in avoiding the same cart, slightly ruffled the skin of his nose. Both were seized with the tetanus; and both died, notwithstanding all possible assistance was given. The former had his thumb amputated without effect.

In the Edinburgh Physical and Literary Essays vol. iii. Dr Donald Monro describes a new method of cure, communicated to him by a gentleman who was formerly a practitioner in Jamaica. While this gentleman practised in that island, he had under his care a great number of cases of tetanus attended with the locked jaw. At first, he used to give very freely of opium, musk, and other medicines of this class; to bleed, and make other evacuations; while he used baths, fomentations, embrocations, and other external applications, but all without the least success; and, as he had lost a great many patients without being so lucky as to make one cure, he began to believe that this disorder always proved fatal, and was not to be cured by medicine, notwithstanding what some practitioners,

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titioners had alleged. However, having received an unexpected hint concerning the good effects of the mercurial ointment in such cases, he resolved to try it; and ordered the first patient that offered to be put into a warm room, and to be rubbed two or three times a day with the ointment, till such time as a salivation was raised; when he with pleasure observed, that, as soon as the mercury began to affect the mouth, the convulsions of the muscles of the jaws, as well as all the other spasms and convulsions, ceased, and the patient was freed of all his complaints. After this, he treated every case of this kind, which came under his care in the same manner, and cured twelve, which were all who applied to him for advice so early in the disorder that there was time to bring the mercury to the mouth before the fatal period was expected. A few died, in whom the disease was so far advanced before he saw them that there was no time to raise a salivation. None of the cases which were under this gentleman's care in the West Indies were the consequences of wounds or capital operations; nor has he had any opportunity of trying it since in cases of the locked jaw, which sometimes follows capital operations, owing to his having given over practice: but he thinks, that from the similarity of the complaint, there is no doubt that the mercurial frictions would be equally efficacious in such cases, as when the disorder comes from catching cold or other such causes.

In the second volume of the Medical Transactions, we have an account of a cure performed by Dr William Carter of Canterbury, by means very different from any of those above related.—On the 17th of May 1767, the doctor was called to a strong healthy man, in the 21st year of his age, and who had been confined to his bed for three weeks. What gave rise to his present disorder was an wound on the inner ankle of the right leg, which he had received six weeks before from a joiner's chisel. At that time his mouth was so far closed, as to admit only the most liquid nourishment, which he constantly sucked through his teeth: but his legs and jaw, and the whole length of the spina dorsi, were quite immoveable, being as stiff and rigid as those of a person long dead; his head was drawn backward, and he was frequently strongly convulsed. The motion indeed of both his arms was but little impaired. From the beginning to the end, his sight, hearing, and memory, continued perfect; his appetite was good; and his senses, in the daytime, entire, though sometimes wandering in the night. As to his pulse, it was regular; if it deviated at all from the pulse of a person in health, it was rather slow than quick, and somewhat fuller than natural. Such was the situation of the patient; a detail of which had been given before the doctor set out on his journey, which he undertook with a determined resolution to make use of the method recommended by Dr Silvester, in the first volume of Medical Observations and Inquiries, published in the year 1757, (and which has been related from Dr Chalmers and Dr Hillary.) But, on his arrival at the house, he found great quantities of the *extractum thebaicum* dissolved had been already given him; and that, for the five last days, he had taken no less than 28 grains of that medicine, with 50 grains of musk, in the space of 24 hours, without any sensible effect, except the bringing on a confused sleep, out of which he frequently awoke in great hurries, attended with a violent pain in the head, which almost deprived him of his senses. The doctor was afraid to extend the dose; and soon determined to take some other method, though at a loss what method to pursue, as, during a course of almost 30 years practice, nothing of the same kind had ever fallen under his cognizance before. Reflecting, however, that this disorder had always been deemed of the spasmodic kind, and that the good effects produced by the *extractum thebaicum* must probably be owing to the relaxing and resolving faculty of that medicine, he directed a blister to be applied between the shoulders, the whole length of the spine; the jaw to be anointed with the *oleum lateritium*; and a purge consisting of the *tinctura sacra*, *tinctura jalappæ*, and the *syrupus de rhamno cathartico*, to be given him. This was repeated three several times afterwards, at the distance of three or four days between each dose. On the intermediate days, he was ordered the *oleum succini*, the fetid gum, and the *oleum amygdalinum*. Of the first he took 30 drops, of the gum 20 grains, and of the last four ounces, in 24 hours. By these means, and these only, the convulsions soon ceased; and he grew daily better and better, till at the end of a fortnight he was able to walk about his room, and in less than three weeks became in all respects well, some small weakness in the parts only excepted. The jaw was relieved first, after that the spine, and last of all the legs. A pain and uneasiness in the places affected, neither of which he had felt before, were the forerunners of his approaching amendment.

Tetanus.

From all this it seems reasonable to conclude, either that there is no certain remedy for tetanus in all cases, or that the medicines which prove effectual in one constitution will fail in another. Thus, it is possible, that in cases where opium proves ineffectual, mercury may be a remedy; and, on the contrary, where mercury fails, opium may be effectual; and even where both are ineffectual, the antispasmodics recommended by Dr Carter may be of use. It is therefore necessary for physicians to be extremely careful to observe the effects of the first doses of their remedies: for if the symptoms show not the least appearance of remission after a large dose of opium, it is improbable that it can be cured by a repetition of the medicine; and as no time can be lost with safety, it will then be proper to apply mercurial ointment, or whatever else may be judged proper.—In the Edinburgh Medical Commentaries we have an account of the cold bath being used as a remedy, by Dr Thomas Cochrane, at that time physician at Nevis. The patient was an East Indian boy, who had been gored by a cow, and afterwards exposed to a rainy damp air for some hours. Dr Cochrane ascribes his cure to the cold bath, which was applied by dashing the water upon his body. But as the patient at the same time got laudanum, at first in the quantity of 200 drops a-day, and afterwards in still larger doses; and had besides his throat and shoulders anointed with warm oil of turpentine, was bled, and had lenient clysters and laxatives; it is by no means easy to say what share the cold bath had in his cure. Dr Cochrane, however, says he has heard of some cases being treated successfully by cold water and cinchona

cinchona in St Eustatia and St Kitt's, and in another letter mentions his having used the cold bath in other cases of tetanus with success. But since Dr Cochrane's publication, a more full and satisfactory account of the benefit of this practice has been communicated in a paper published by Dr Wright, in the sixth volume of the London Medical Observations. Dr Wright gives a particular account of six cases, in which the best effects were obtained from dashing cold water upon the patient; and he observes, that since he first used this method of cure he never failed in one instance to effect a recovery, and that in a shorter time than by any other method hitherto proposed. This practice has on some occasions been adopted by practitioners in Britain, although here the disease is a much less frequent occurrence. It has particularly been employed with success by Dr Currie of Liverpool; and we hope that still more extensive practice will confirm the benefit to be derived from it, although not in every instance, yet in many cases of this affection. We are, however, sorry to say that we have of late heard of several cases in which it has been tried in Britain, and which, notwithstanding the use of it, had a fatal termination.

Very lately a different mode of cure in this affection has been recommended by Dr Rush, professor of medicine in Philadelphia, in a paper entitled Observations on the Cause and Cure of Tetanus, published in the second volume of the Transactions of the American Philosophical Society. Dr Rush, viewing tetanus as being a disease occasioned by relaxation, thinks the medicines indicated to cure it are such only as are calculated to remove this relaxation, and to restore tone to the system. On this ground he recommends the liberal use of wine and cinchona; and tells us, that he has employed them with success in actual practice. When the disease arises from an wound of any particular place, he recommends stimulants to the part affected; such as dilatation of the wound, and filling it with the oil of turpentine. How far this practice will be confirmed by more extensive experience, we cannot take upon us to determine. We may only observe, that a very contrary practice has been recommended as highly successful by some practitioners in Spain, where tetanic affections are a very frequent occurrence in consequence of slight accidents. There gentle emollients are strongly recommended, particularly immersing the wounded part in tepid oil for the space of an hour or so at a time, and repeating this application at short intervals. By this mode many cases, after very alarming appearances had taken place, are said to have been completely and speedily removed. While the practice is very simple, it appears at the same time in many respects very rational, and may perhaps be considered as well deserving a trial in the first instance.

Among other remedies employed in tetanus it has been said that the spasms have sometimes been allayed by a strong electric shock. And in obstinate cases electricity or galvanism certainly well deserve a trial.

Genus XLIX. TRISMUS.

280 The *Locked Jaw*.

Trismus, *Sauv.* gen. 117. *Lin.* 124. *Sag.* gen. 223. Capistrum, *Vog.* 208.

281 Sp. I. *Trismus Nascentium*.

Locked Jaw in children under two months old.

Trismus nascentium, *Sauv.* sp. 1. *Heister Comp.* Med. Pract. cap. xv. § 10. *Cleghorn* on the Diseases of Minorca, Introd. p. 33. *Hofer.* in Act. Helvet. tom. i. p. 65.

This distemper is so closely connected with the tetanus, that it ought rather to be accounted a symptom of the tetanus than a primary disease. And nothing need now be added to what has been said respecting tetanus.

Sp. II. The *Trismus* from *Wounds* or *Cold*. 282

Trismus traumaticus, *Sauv.* sp. 2. *Lond. Med. Obs.* vol. i. art. 1, 7. Vol. ii. 34. Vol. iii. 31. Vol. iv. 7.
Angina spasmodica, *Sauv.* sp. 18. *Zwingeri*, Act. Helvet. tom. iii. p. 319.
Convulsio à nervi punctura, *Sauv.* sp. 2.
Trismus catarrhalis, *Sauv.* sp. 15. *Hillary's* Barbadoes, 221. *Lond. Med. Obs.* vol. iv. 7.

The internal remedies proper in all cases of the locked jaw, from whatever cause it may proceed, have been already mentioned under Tetanus: the external treatment of wounded parts which may give occasion to it belongs to the article Surgery. But of this also we have offered some observations under the head of Tetanus; and, indeed, trismus may be considered as being merely an incipient tetanus, or rather a slight degree of that disease.

Genus L. CONVULSIO.

Convulsions. 283

Convulsio, *Sauv.* gen. 128. *Lin.* 142. *Vog.* 191. *Sag.* gen. 235.
Convulsio universalis, *Sauv.* sp. 11.
Hieranosos, *Lin.* 144. *Vog.* 190.
Convulsio habitualis, sp. 12.
Convulsio intermittens, *Sauv.* sp. 16.
Convulsio hemitotonos, *Sauv.* sp. 15.
Convulsio abdominis, *Sauv.* sp. 10.
Convulsio ab inanitione, *Sauv.* sp. 1.
Convulsio ab onanismo, *Sauv.* sp. 13.
Scelotyrbe festinans, *Sauv.* sp. 2.

Description. When convulsions attack only particular parts of the body, they are generally attended with some kind of paralysis at the same time, by which means the affected parts are alternately convulsed and relaxed; a permanent convulsion, or unnatural contraction of particular muscles, is called a *spasm* or *cramp*. These partial convulsions may attack almost any part of the body; and are not unfrequently symptomatic, in fevers, the cholera morbus, &c. The involuntary startings of the tendons, the picking of the bedclothes, &c. in acute diseases are all of them convulsive disorders. Convulsions, even when most generally extended, differ from epilepsy in not being attended with any mental affection or abolition of sense, and not followed by the same torpid state.

Causes. Convulsions, not only of particular parts, but also over the whole body, often take place from causes not very evident. Sometimes they seem to depend

Spasmi. pend on a certain delicacy or irritability of the nervous system, which is framed with such exquisite sensibility as to be strongly affected by the slightest causes. Delicate women are often subject to hysterical convulsions, and also hyponchondriac people. Convulsions, however, often take their rise from wounds, irritations of the stomach and intestines by worms, poisons, violent cathartics and emetics, &c.; and very often they are symptomatic, as in dentition, the smallpox, and many kinds of fevers.

Prognosis. Except in some few cases, convulsive disorders are always to be dreaded; but less in young people than in such as are advanced in life. Those which attack girls under the age of puberty, will generally cease on the appearance of the menses; and boys have likewise a chance of being relieved as they advance in life: but in grown-up people, unless the cause be very evident, a cure is hardly to be expected, especially after the disease has been of long continuance.

Cure. The treatment is very much the same with that of epilepsy, afterwards to be considered: but a recovery is most frequently obtained by the removal of the existing cause.

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Genus LI. CHOREA.

St Vitus's Dance.

Scelotyrbe, *Sauv.* gen. 136. *Sag.* 243.
Chorea, *Lin.* 139.
Scelotyrbe chorea Viti, *Sauv.* sp. 1.
Chorea St Viti, *Sydenh.* Sched. Monit.

Description. This disease shows itself first by a kind of lameness or instability of one of the legs, which the patients draw after them in a ridiculous manner: nor can they hold the arm of the same side still for a moment; for if they lay it on their breast, or any other part of their body, it is immediately forced away by a convulsive motion. If they be desirous of drinking, they use a number of odd gesticulations before they can bring the cup to their mouths, because their arms are drawn this way and that by the convulsions which affect them.

Causes, &c. The general cause of St Vitus's dance is a debility of the system; and hence we find it attacks only weakly boys, and more especially girls, when under the age of puberty. But the particular causes determining the muscles to be affected in such and such a manner are entirely unknown.

Prognosis. As this disorder scarce ever attacks any persons but such as are under the age of puberty, there is almost a certain prospect of its being then cured, though generally the disorder is easily removed before that time.

Chorea, however, in some instances, proves an obstinate affection; but is hardly in any instance attended with danger.

Cure. It has hitherto been almost universally the common practice to treat this disease with antispasmodics and tonics, particularly opium, hyosciamus, valerian, cinchona, preparations of iron, zinc, and copper, and cold bathing; and under the use of these the disease has, in general, been removed. But Dr James Hamilton, senior physician to the Royal Infirmary of Edinburgh, in a treatise which he has lately published on the use of purgative medicines, has recommended a very different practice in this disease, the use, viz. of brisk cathartics: these he advises to be repeated daily for some time. The great object, however, which he has in view, is not to evacuate from the system, but to produce a thorough and complete evacuation of the intestinal canal. He finds, that by the first doses, large quantities of black-coloured matter are discharged; and he recommends that the use of the purgatives should be persisted in till the stools assume a natural appearance. In confirmation of the utility of this practice, he has related several cases in which it produced a speedy and complete cure; and equal success has attended this practice when directed by several others. There can therefore be no hesitation in recommending it at least in every obstinate instance of chorea. Raphania.

Genus LII. RAPHANIA. 285

Raphania, *Lin.* 155. *Vog.* 143. *Lin.* Amœn. Acad. vol. vi.
Convulsio raphania, *Sauv.* sp. 7.
Eclampsia typhodes, *Sauv.* sp. 1. *Sennert.* de febr. l. iv. cap. 16. *Gregor. Horst.* Oper. tom. ii. l. viii. obs. 22. *Brunner* in Ephem. Germ. D. iii. A. ii. obs. 224. *Willisch.* ibid. cent. vii. obs. 13. *Wepfer.* de Affect. Capitis, obs. 120. *Breslauer* Sammlung 1717, Julio, Septembri, et Decembr. ibid. 1723, Januar. A. N. C. vol. vii. obs. 41. *Bruckmann.* Comb. Norimb. 1743, p. 50.

Description. According to Sauvages, this distemper begins with a lassitude of the limbs, transient colds and shiverings, pain of the head, and anxieties of the præcordia. Then come on spasmodic startings of the fingers and feet; also of the tendons and muscles, conspicuous below the skin. The disease is attended with heat, fever, delirium, stupor, constriction of the breast, suffocating dyspnœa, loss of voice, horrid convulsions of the limbs, preceded by a formication, or sensation as of ants or other small insects creeping on the parts. In this state of the disease, the convulsive paroxysms are attended with most violent pains in the limbs, vomiting, or diarrhœa, with the passing of worms, thirst, and in young people an unnatural hunger. It continues from ten days to three months. About the eleventh or twentieth day, some are relieved by copious sweats, or purple exanthemata: while others fall into a tabes, with stupor, or stiffness of the joints.

Causes, &c. This disease is frequently epidemic in Suabia and other parts of Germany; where it is said to be produced by seeds of radishes, which are often mixed with rye in that country; and from this supposed cause the disease takes it name. It is also, however, a very common opinion, that this disease depends on the rye used in diet being of a bad quality, and particularly containing a large proportion of what is called *spurred rye*.

Cure. In this affection, the cure, as far as it has yet been discovered, is very much the same with that of epilepsy, the disease next to be considered. But from what has been said of the advantages derived from the use of purgatives in chorea, analogy would lead us to make a trial of them also in cases of raphania.

Genus LIII. EPILEPSIA.

Falling-sickness.

Epilepsia, *Sauv.* gen. 134. *Lin.* 143. *Vog.* 188. *Sag.* gen. 24. *Boerh.* 1071. *Hoffm.* III. 9. *Junck.* 54.
Eclampsia, *Sauv.* sp. 133. 180. *Sag.* gen. 240.

Sp. I. The *Cerebralis*, or *Epilepsy* depending on an affection of the *Brain*.

Epilepsia plethorica, *Sauv.* sp. 1.
Eclampsia plethorica, *Sauv.* sp. 7.
Epilepsia cachectica, *Sauv.* sp. 2.

Sp. II. The *Sympathica*, or *Sympathetic Epilepsy*, with a sensation of something rising from a certain part of the body towards the head.

Epilepsia sympathica, *Sauv.* sp. 8.
Epilepsia pedisymptomatica, *Sauv.* sp. 6.

Sp. III. The *Occasionalis*, or *Epilepsy* arising from various irritating causes.

Epilepsia traumatica, *Sauv.* sp. 13.
Eclampsia traumatica, *Sauv.* sp. 9.
Epilepsia à dolore, *Sauv.* sp. 10.
Epilepsia rachialgica, *Sauv.* sp. 14.
Eclampsia à doloribus, *Sauv.* sp. 4.
a, Rachialgica.
b, Ab otalgia.
c, A dentitione.
Eclampsia parturientium, *Sauv.* sp. 3.
Eclampsia verminosa, *Sauv.* sp. 2.
Eclampsia ab atropa, *Sauv.* sp. 11.
Eclampsia ab œnanthe, *Sauv.* sp. 12.
Eclampsia à cicuta, *Sauv.* sp. 13.
Eclampsia à coriaria, *Sauv.* sp. 14.
Epilepsia exanthematica, *Sauv.* sp. 11.
Epilepsia cachectica, *Sauv.* sp. 2.
Epilepsia stomachica, *Sauv.* sp. 3.
Eclampsia à saburra, *Sauv.* sp. 5.
Epilepsia à pathemate, *Sauv.* sp. 7.
Eclampsia ab inanitione, *Sauv.* sp. 8.
Epilepsia neophytorum, *Sauv.* sp. 15.

Description. The epilepsy often attacks suddenly, and without giving any warning: but more frequently is preceded by a pain in the head, lassitude, some disturbance of the senses, unquiet sleep, unusual dread, dimness of sight, a noise in the ears, palpitation of the heart, coldness of the joints; and in some there is a sensation of formication, or a cold air, &c. ascending from the lower extremities towards the head. In the fit, the persons fall suddenly to the ground (whence the name of the *falling-sickness*), frequently with a violent cry. The thumbs are shut up close in the palms of the hands, and are with difficulty taken out; the eyes are distorted, so that nothing but the whites are to be seen; all sensation is suspended, insomuch, that by no smell, noise, or otherwise, nor even by pinching the body, can they be brought to themselves; they foam at the mouth, with a hissing kind of noise; the tongue is frequently lacerated by the teeth, and there is a violent convulsive motion of the arms and legs. Sometimes, however, the limbs, instead of being agitated by convulsive motions, are all stiff, and the patients are as immoveable as a statue. In children, the penis is erected; and in young men there is an emission of the semen, and the urine is often thrown out to a considerable distance. At length there is a remission of the symptoms, and the patients recover after a longer or shorter interval; when they complain of a pain, torpor, or heaviness of the head, with a lassitude of all the joints.

Causes, &c. The dissection of epileptic subjects has shown a variety of morbid appearances, which may be supposed to have contributed to the disease; such as, indurations in the brain or meninges; caries of the internal surface of the cranium; projections of the bony substance of the same, pressing upon the brain; collections of serum or purulent matter, and earthy concretions within the skull; besides many others which are recorded by Bonetus, Morgagni, and Lieutaud. But often the causes are impossible to be discovered; for even in those who have died of the disease, the brain and all other parts of the nervous system have been apparently sound. The disease will attack strong as well as weak people; and in those who are subject to it, any considerable excess in drinking, a surfeit, violent passion, or venery, &c. will certainly bring on a fit. Some have epileptic paroxysms returning periodically after considerable intervals; and the disease has been thought to have some dependence on the phases of the moon.

Prognosis. If the epilepsy comes on before the time of puberty, there are some hopes of its going off at that time. But it is a bad sign when it attacks about the 21st year, and still worse if the fits grow more frequent; for then the animal functions are often destroyed, as well as those of the mind, and the patient becomes stupid and foolish. Sometimes it will terminate in melancholy or madness, and sometimes in a mortal apoplexy or palsy. It has sometimes, however, been observed, that epilepsies have been removed by the appearance of cutaneous diseases, as the itch, smallpox, measles, &c. While the disease is recent, therefore, we are not to despair of a cure; but if it be of long standing, or hereditary, there is very little reason to expect that it can be removed.

Cure. From the symptoms occurring in epilepsy, which consists of involuntary convulsive motions, and an affection of the mental powers, there is reason to conclude that the fit immediately depends on the induction of some peculiar action of the brain; but that convulsions may ensue from this cause, it would seem necessary that there should also occur a peculiar disposition to action in the moving fibres. On this ground, then, we may suppose the cure to be chiefly expected on one of two principles; either by our being able to prevent the peculiar action of the brain, or to remove the disposition to action in the moving fibres. The first is chiefly to be accomplished by the removal of irritating causes, by preventing their influence from being propagated to the brain, when they are applied to remote parts; or by counteracting their influence, from inducing in the brain a state of action different from that to which they give rise. The second end is chiefly to be obtained by diminishing the mobility of the nervous energy, and by strengthening

Spasmi. ening the tone of the moving fibres. It must, however, be allowed, that in all convulsive disorders, excepting those which are cured by nature about the time of puberty, the cure by artificial means is very difficult. Numberless specifics have been recommended, but all of them have failed of answering the expectation. When the cause can be discovered, that must be removed. In other cases, the cold bath, valerian root, castor, musk, opium, the fetid gums, cinchona, with the whole tribe of nervous and antispasmodic medicines, have been recommended: but none of those, or indeed any combination of them, have been found generally useful; though the slighter, or symptomatic cases, may often be removed by them.

Of late the *calx* or *oxide*, improperly called the *flowers*, of zinc, have obtained such reputation in convulsive disorders as to be received into the Edinburgh Pharmacopœia under the title of *oxidum zinci*. They were proposed by Dr Gaubius as an antispasmodic, in his *Adversaria;* and their efficacy has since been confirmed by various observations. In an inaugural dissertation published by Dr Hart at Leyden, the medical virtues of the flowers of zinc are considered. He observes, that they have long been used externally, chiefly for inflammations of the eyes from acrid lymph. Glauber first proposed the internal use of them; and Gaubius discovered them to be the remedy of a celebrated empiric Luddemannus, which he styled his *luna fixata*. After this he exhibited them with success in convulsive and spasmodic diseases. Dr Hart supposes, that they act either as absorbents, or as possessing a specific virtue: but is a strong advocate for their efficacy, on whatever principles they may operate; and, in favour of his opinion, relates seven cases in which they proved successful. A girl of 17 years of age was seized with a slight *chorea* from a fright; and when the disease had continued six days, she began to take the flowers of zinc, by which her disorder was removed in less than three weeks. Her cure required only 16 grains of the zinc. In a few months the complaints returned, from the same cause; and were removed by four grains of the medicine divided into 10 doses. A boy of about four years old, labouring under a real epilepsy, suspected to be hereditary, was cured by a grain of the flowers of zinc taken every day for some time.—A man 50 years old, thrown into convulsions from a violent passion, was cured by a grain of the calx taken every two hours. The disease had gone off upon venesection and the use of some other remedies; but returned again in two weeks, when it was finally removed by the zinc. The two last cases are related from Dr Gaubius, who affirms that he has used the flowers of zinc in cases of the chincough, hysteric hiccough, and spasmus cynicus; that they frequently did more than other medicines, but were by no means successful in every case. The other cures mentioned by Dr Hart are similar to those above mentioned. But it does not appear that he ever saw a confirmed epilepsy cured by this medicine.

In the first volume of the Edinburgh Medical Commentaries, we have an account by Mr Benjamin Bell, of a man afflicted with a confirmed epilepsy, who was considerably relieved by the flowers of zinc.

In a young man labouring under the epilepsy, in whom the fits were preceded by an *aura epileptica*, or sensation like air arising from the inside of the knee-joint, the disease was also relieved, but not cured. Epilep.

Dr Percival relates some cases of epilepsy which seem to have been cured by the flowers of zinc; and in other cases, where the disease was not entirely removed by it, the spasms were nevertheless much mitigated. He did not observe that it promoted any evacuation; excepting that in some, upon being first taken, it occasioned a little sickness, which went off with a stool. He adds, that those apothecaries who do not prepare this medicine themselves, are in great danger of being imposed upon, as it is sometimes a mere corrosion of the zinc by an acid, and even imperfectly washed.

The good effects of the oxide of zinc as an antispasmodic are also attested by Dr Haygarth of Chester and Dr White of York. The former gives a test of their goodness which may be of use to those who do not prepare them, namely, that the true flowers of zinc, when strongly heated, become yellow, but re-assume their white colour on being allowed to cool. The latter gives a case of hieranosos, or strange convulsions of almost all the muscles of the body, cured by zinc, after a number of other remedies had failed. But, although from these and other respectable authorities, there can be no doubt that zinc has often been successful in epilepsy; yet it is equally certain, that in many others it has had a fair trial, without producing any benefit.

In Dr Home's clinical experiments and histories, also, oxide of zinc is mentioned as having been found serviceable upon trial in the Royal Infirmary of Edinburgh. Of the other principal remedies which have been recommended for the epilepsy and other convulsive disorders allied to it, we have the following account by the same author.

1. *The cold-bath* was tried in one who had a convulsive disorder of one side, but the symptoms were rendered much worse by it.

2. *Venesection.* Not to be depended on in convulsions.

3. *Electricity.* In two convulsive cases was of no service.

4. *Epispastics.* Do not seem to be powerful antispasmodics.

5. *Valerian.* In nine convulsive cases, for which this remedy has been reckoned almost a specific, it not only made no cure, but could scarcely be reckoned to do any good. Dr Home supposes that it acts as a bitter tonic, something like the *serpentaria Virginiana.* Though much used at present, he tells us it has always appeared to him a weak, often a hurtful, medicine.

6. *Musk.* Six convulsive patients treated with large doses of this remedy, were neither cured nor in the least relieved.

7. *Castor* seems to be unworthy of the confidence formerly put in it. It is indeed possessed of a sedative power, and therefore may be useful in spasmodic feverish cases.

8. *Asafœtida* has considerable antispasmodic powers, but is not always successful. It heats and quickens the pulse; and is therefore improper in cases attended with inflammation. It disagrees with some from a peculiarity of constitution; exciting pain in the stomach, and

Spasm.

and vomiting: but this can be known only after the exhibition of the medicine.

9. *Cinchona.* Of seven spasmodic cases, six were either cured or mitigated. An epilepsy of eight years standing was very much relieved by taking the bark for a month, and one of two years standing by taking it for ten days. But the medicine is of a heating nature, and therefore is not to be employed in cases attended with inflammatory symptoms.

10. *Peony root* was given to two epileptic patients without the least success.

11. *Viscus quercinus*, or misletoe, was given in the quantity of two scruples five times a-day to an epileptic patient, without success.

12. *Extractum hyosciami* was given to an epileptic patient, to one afflicted with the hemitotonos, and to one who laboured under the hysteric affection, without the least good effect.

13. *Folia aurantiorum* were exhibited with the like bad success. Five drams of the powdered leaves were taken at once without any sensible effect.

14. *Cardamine pratensis*, in three epileptic cases, was not attended with any success.

15. *Opium* did no good.

16. *Ammoniaretum cupri* made no cure in four cases of epilepsy in which it was tried.

That in many cases all these remedies have been employed without success, is not to be denied: and indeed it may with confidence be asserted, that a great majority of cases of epilepsy are incurable by any remedy that has yet been discovered. At the same time, as there is incontrovertible evidence that some of them have succeeded at least in certain cases, the more powerful may always be considered as deserving a fair trial. The ammoniaretum cupri, in particular, seems well entitled to the attention of practitioners; for though it be a medicine of great activity, yet under prudent administration it may be employed even with very young subjects without any hazard; and in several inveterate cases, which had obstinately resisted other medicines, it has brought about a complete recovery.

Genus LIV. PALPITATIO.

Palpitation of the Heart.

Palpitatio, *Sauv.* gen. 130. *Lin.* 132. *Vog.* 213. *Sag.* 237. *Hoffm.* III. 83. *Junck.* 33.

The palpitation of the heart is sometimes so violent, that it may be heard at a considerable distance. It may proceed from a bad conformation of the heart itself, or some of the large vessels. It may also be occasioned by wounds or abscesses in the heart; or it may proceed from polypous concretions or ossifications of that viscus, or from plethora, fear, or spasmodic affections of the nervous system. When it proceeds from diseases of the heart or large vessels, it is absolutely incurable. In spasmodic cases, the remedies above related may be used. If the patient be plethoric, bleeding will probably remove the disorder, at least for the present.

Genus LV. ASTHMA.

Asthma, *Sauv.* gen. 145. *Lin.* 161. *Vog.* 268. *Sag.* gen. 282.

Asthma convulsivum, et spasmodico-flatulentum, *Hoffm.* III. 94. Asthma.

Asthma spasticum, *Junck.* tab. 51.

Sp. I. *Spontaneous Asthma.*

Asthma humidum, *Sauv.* sp. 1. Flatulentum, *Floyer* on the Asthma, chap. i.

Asthma convulsivum, *Sauv.* sp. 2. *Willis* Pharm. rat. P. II. sect. i. cap. 12.

Asthma hystericum, *Sauv.* sp. 3. *Floyer* on the Asthma, chap. i.

Asthma stomachicum, *Sauv.* sp. 8. *Floyer*, Scheme of the species of Asthma. Periodic Asthma, 6.

Orthopnœa spasmodica, *Sauv.* sp. 3.

Orthopnœa hysterica, *Sauv.* sp. 4.

Sp. II. The *Exanthematic Asthma.*

Asthma exanthematicum, *Sauv.* sp. 11.

Asthma cachecticum, *Sauv.* sp. 13.

Sp. III. The *Plethoric Asthma.*

Asthma plethoricum, *Sauv.* sp. 15.

The asthma is a chronic disease, which may continue to give very great distress, at intervals, for a considerable number of years. Sir John Floyer, when he wrote his celebrated treatise, had laboured under repeated paroxysms for thirty years.

The common distinction is into *humid* and *dry*; the former is accompanied with an expectoration of mucus or purulent matter, but the latter is not. In the genuine humoral asthma, the patients are obliged to lean forward; the inspiration is short and spasmodic; and the expiration very slow.

Asthmatic persons have generally some warning of the attack, from a languor, loss of appetite, oppression, and swelling of the stomach from flatulence, which precede the fit; but it is usually in the middle of the night that the violent difficulty of breathing comes on.

The duration of the paroxysm is uncertain, as it will sometimes terminate in three or four hours, while at other times it will continue for as many days; nay, it has been known to last three weeks without intermission. While it subsists, the patient is in very great distress, not being able to lie in bed, nor scarcely to speak or expectorate, so great is the difficulty of breathing: and yet, notwithstanding all this apparent interruption to the free passage of the blood through the lungs, an inflammation here seldom or never supervenes a fit of the asthma. As the paroxysm wears off, and the breathing becomes free, there is more or less of an expectoration of mucus; and the urine, from being pale and limpid, becomes high coloured, and lets fall a copious sediment.

In order to obtain relief in the fit, we must sometimes bleed, unless extreme weakness or old age should forbid, and repeat it according to the degrees of strength and fulness: a purging clyster, with a solution of asafœtida, must be immediately injected; and if the violence of the symptoms should not speedily abate, it will be proper to apply a blistering plaster to the neck or breast.

In the height of the paroxysm, an emetic might be followed

Spasmi. followed by dangerous symptoms, as it would increase the accumulation of blood in the vessels of the head; but vomiting will often prevent a fit of the asthma, especially if the stomach should chance to be loaded with any sort of saburra. A very strong infusion of roasted coffee has been found to give ease in an asthmatic paroxysm.

Sir John Pringle says it is the best abater of the paroxysms of the periodic asthma that he has seen. The coffee ought to be of the best Mocco, newly burnt, and made very strong immediately after grinding it. He commonly ordered an ounce for one dish; which is to be repeated fresh after the interval of a quarter or half an hour; and which is to be taken without milk or sugar. The medicine in general is mentioned by Musgrave in his treatise *de Arthritide anomala;* but he first heard of it from a physician in Litchfield, who had been informed by the old people of that place, that Sir John Floyer, during the latter part of his life, kept free from, or at least lived easy under, his asthma, from the use of very strong coffee. This discovery, it seems, he made after the publication of his book upon that disease. Dr Percival says he has frequently directed coffee in the asthma with great success.

In the intervals of the fit, persons subject to the asthma, especially the humid species, should take emetics from time to time. An infusion of tobacco is an emetic that has been said to be very serviceable in some asthmatic cases; but its operation is both so distressing and so dangerous, that it will never probably be introduced into common use as an emetic. Smoking or chewing the same has been known to prevent the frequency and severity of the paroxysms. Asthmatic patients may also use the *lac ammoniaci*, with a due proportion of *oxymel scilliticum* and *vinum antimoniale*, with a view to promote expectoration; or the gum ammoniac, and others of similar virtues, may be formed into pills, and combined with soap, as mentioned for the dyspnœa pituitosa; or a mass may be composed of asafœtida and balsam of Tolu, with syrup of garlic; and these pills may be washed down by a medicated wine, impregnated with squills, horse-radish root, and mustard seed; or a strong bitter infusion, with a little antimonial wine.

In some cases crude mercury will be found serviceable; in others flowers of sulphur, made into an electuary with honey or syrup of garlic; and if, notwithstanding the use of these things, a costive habit should prevail, it will be necessary, from time to time, to give a few grains of pills of aloes and myrrh, soap and aloes, or a mass of equal parts of rhubarb, scammony, and soap.

The *dry* or *spasmodic asthma*, during the extreme violence of the fit, is best relieved by opiates; and sometimes very large doses are required. But in order to obtain permanent relief, nothing is found to answer better than ipecacuanha in small doses. Three, five, eight, or ten grains, according to the strength and constitution of the patient, given every other day, have been productive of the happiest effects; acting sometimes as an evacuant, pumping up the viscid phlegm; at others, as an antispasmodic or sedative. Issues are generally recommended in both species, and will often be found useful.

Changes of weather are usually felt very sensibly by asthmatic people, who in general cannot live with tolerable ease in the atmosphere of large cities; though we shall sometimes meet with patients who agree better with this air, which is so replete with gross effluvia of various kinds, than with the purest that can be found in country situations. And some are found who breathe with the most ease in a crowded room, with a fire and candles.

A light diet of meats that are easy of digestion, and not flatulent, is requisite for asthmatic people; and the exercise of riding is often highly serviceable.

When the asthma is found to depend on some other disease, whether it be the gout or an intermittent fever, or when it proceeds from the striking in of some cutaneous eruption, regard must always be had to the primary disease: thus, in the *asthma arthriticum*, sinapisms to the feet, or blistering, will be absolutely necessary, in order, if possible, to bring on a fit of the gout. And when the dregs of an ague give rise to an asthma, which is termed *febriculosum*, and invades at regular intervals, we must have recourse to the Peruvian bark. The *asthma exanthematicum* will require blisters or issues, to give vent to the acrid matters which were repelled from the surface of the body; and courses of sulphureous waters, goats whey, and sweetening diet drinks, or perhaps mercurial alteratives, in order to correct the sharpness of the juices.

Dyspnœa.

Genus LVI. DYSPNOEA. 29[illegible]

Habitual Difficulty *of* Breathing.

Dyspnœa, *Sauv.* gen. 144. *Lin.* 160. *Vog.* 267. *Sag.* 251. *Junck.* 32.

Sp. I. The *Catarrhal* Dyspnoea. 29[illegible]

Asthma catarrhale, *Sauv.* sp. 16.
Asthma pneumonicum, *Willis* Pharm. rat. P. II. sect. i. cap. 12.
Asthma pituitosum, *Hoffm.* III. sect. ii. cap. 2. § 3.
Asthma pneumodes, *Sauv.* sp. 17.

This is readily known by the symptoms of pneumonia and catarrh attending it; and to the removal of these symptoms the care of the physician must be principally directed.

Sp. II. The *Dry* Dyspnoea. 29[illegible]

Dyspnœa à tuberculis, à hydatibus, &c. *Sauv.* sp. 2, 4, 5, 20.
Orthopnœa à lipomate, *Sauv.* sp. 18.

This is generally accompanied with a phthisis pulmonalis; but Sauvages mentions one species of phthisis to which the dry dyspnœa seems more particularly to belong. The patients fall away by degrees, and have a great difficulty of breathing, continual thirst, and little or no spitting. When opened after death, their lungs are found not to be ulcerated, but shrivelled and contracted as if they had been smoke-dried. Goldsmiths and chemists are said to be subject to this disease, by reason of the vapours they draw in with their breath. Sauvages doth not mention any particular remedy. Shortness of breath arising from *tubercles*, as they are termed, or a scirrhous enlargement of the lymphatic glands which are dispersed through the lungs, is commonly

monly found in scrophulous habits, and may be distinguished by the concomitancy of those external swellings and appearances which particularly mark the scrophula. This species of dyspnœa generally ends in a phthisis. Courses of goats whey, and of sea water, have been known to do service; but it must be confessed, that a perfect cure is seldom obtained. Issues are of use in these cases, as they appear to prevent the ill effects of over fulness, if it should happen at any time to supervene.

95 Sp. III. *Dyspnoea* from *Changes* in the *Weather*. (*Sauv.* sp. 12.)

This seems to be a disease entirely spasmodic, and the antispasmodics already related are accordingly indicated.

96 Sp. IV. The *Dyspnoea* from *Earthy Substances* formed in the *Lungs*.

Sauvages mentions this disease as much more common in brutes than in the human race: but Dr Cullen mentions his having seen some instances of it; and we have several accounts by different authors of calculous matters being coughed up by people labouring under a dyspnœa, and threatened with consumption. In three cases of this kind which fell under Dr Cullen's inspection, there was no appearance of earthy or stony concretions in any other part of the body. The calcareous matter was coughed up frequently with a little blood, sometimes with mucus only, and sometimes with pus. In one of these cases, an exquisite phthisis came on, and proved mortal: in the other two the symptoms of phthisis were never fully formed; and after some time, merely by a milk diet and avoiding irritation, the patients entirely recovered.

Sauvages also greatly recommends milk in these cases, and soap for dissolving the concretions. The reason why brutes are more subject to these pulmonary calculi than mankind, is, that they very seldom cough, and thus the stagnating mucus or lymph concretes into a kind of gypseous matter.

297 Sp. V. The *Watery Dyspnoea*.

Dyspnœa pituitosa, *Sauv.* sp. 1.
Orthopnœa ab hydropneumonia, *Sauv.* sp. 12.

This may arise from too great a defluxion of mucus on the lungs, or from an effusion of serum, as is mentioned under the pneumonia. The treatment of the disease may be gathered from what has been already said under the heads of Pneumonia, Catarrh, Empyema, &c.

298 Sp. VI. The *Dyspnoea* from *Corpulency*.

Orthopnœa à pinguedine, *Sauv.* sp. 6.

There have been many instances of suffocation and death occasioned by too great corpulency. These fatal effects, however, may be almost always avoided, if the persons have resolution to persist in an active and very temperate course of life; avoiding animal food, much sleep, and using a great deal of exercise. In the third volume of the Medical Observations, however, there is an extraordinary instance of internal obesity which neither showed itself externally, nor could be removed by any medicines.

Pertussis.

Other species of dyspnœa have been considered under Phthisis. It is frequently symptomatic of diseases of the heart and large vessels, or swellings of the abdomen, &c.

Genus LVII. PERTUSSIS.

Chincough.

299 Pertussis, *Sydenham*, Ed. Leid. p. 200, 311, 312. *Huxham* de aëre, ad ann. 1732.
Tussis convulsiva, sive ferina, *Hoffm.* III. 111.
Tussis ferina, *Sauv.* sp. 10. *Sag.* sp. 10.
Tussis convulsiva, *Sauv.* sp. 11. *Sag.* sp. 11.
Amphimerina tussiculosa, *Sauv.* sp. 13.

Description. This disease comes on at first like a common cold; but is from the beginning attended with a greater degree of dyspnœa than is common in catarrh; and there is a remarkable affection of the eyes, as if they were swelled, and a little pushed out of their sockets. By degrees the fits of coughing become longer and more violent, till at last they are plainly convulsive, so that for a considerable time the patient cannot respire, and when at last he recovers his breath, inspiration is performed with a shrill kind of noise like the crowing of a cock. This kind of inspiration serves only as an introduction to another convulsive fit of coughing, which is in like manner followed by another inspiration of the same kind; and thus it continues for some time, very often till the patient vomit, which puts an end to the paroxysm at that time. These paroxysms are attended with a violent determination of the blood towards the head, so that the vessels become extremely turgid, and blood not unfrequently flows from the mouth and nose. The disease is tedious, and often continues for many months. It is not commonly attended with fever, unless at the commencement.

Causes, &c. The chincough is an infectious disorder, and very often epidemic: but the nature of the contagion is not understood; at least it is no farther understood than that of smallpox, measles, or similar epidemics. We well know that it is from a peculiar and specific contagion alone that this disease, as well as the others above mentioned, can arise. But with regard to the nature of any of them, we are totally in the dark. It generally attacks children, or adults of a lax habit, making its attack frequently in the spring or autumn; at the same time, when this contagion is introduced into any town, village, or neighbourhood, it will rage epidemically at any season. Those alone are affected with this disease who had never before been subjected to it. For in this affection, as well as in smallpox, having had the disease once, gives defence against future contagion. Every individual, however, does not seem to be equally readily affected with this contagion; like other contagious diseases occurring only once in a lifetime, it may naturally be expected to be more frequent among children than at any other period of life. But many, though frequently exposed to contagion, are yet not affected with the disease: and those children who live upon unwholesome watery food, or breathe unwholesome air, are most liable to its attack, or at least suffer most

Spasmi.

most from them. In general it has been concluded, that whatever weakens the solids, or tends to bring on a dissolution of the fluids, predisposes to this disease, and increases its severity.

Prognosis. The chincough is not very often fatal. During one epidemic, however, it is often observed to be much more dangerous and more severe than during another. This is also remarked with regard even to particular periods of the same epidemic; and it is also observed, that on certain families this disease is much more severe than on others. Its danger, however, is still more connected with the period of life at which it occurs. In children under two years of age it is most dangerous; and kills them by producing convulsions, suffocation, inflammation, and suppuration of the brain or in the lungs, ruptures, and incurvation of the spine. In pregnant women it will produce abortion; and in adults inflammations of the lungs, and all the consequences of pneumonia, more frequently than in children. From a long continuance of the disease patients will become asthmatic, ricketty, and scrofulous. It is generally reckoned a good sign when a fit terminates by vomiting; for in this disease there seems to be a great increase of the secretion of mucus, and the vomiting affords great relief.

Cure. Pertussis is one of those diseases which, after the contagion has exerted its influence, can be terminated only by running a certain course: but it is much less limited in its course than smallpox and measles, and often it runs on to a very great length, or at least it is very difficult to distinguish certain sequelæ of this disease from the disease itself. And when it exists in the former of these states, it admits of an artificial termination. In the treatment of this affection, therefore, the objects at which a practitioner chiefly aims, are in the first place, the obviating urgent symptoms, and forwarding the natural termination of the disease; and secondly, the inducing an artificial termination. With these intentions various practices are employed on different occasions. The most approved remedies are vomits, purges, bleeding, and the attenuating pectorals; for the other kinds generally do hurt: but large evacuations of any kind are pernicious. In the Medical Observations, vol. iii. Dr Morris recommends castor. and cinchona: but in cases attended with any degree of inflammation, the latter must certainly do hurt, and the former will generally be insignificant. Dr Butter, in a dissertation expressly on the subject, relates 20 cases of it cured by the extract of hemlock. He directs half a grain daily for a child under six months old; one grain for a child from six months to two years; afterwards allowing half a grain for every year of the patient's age till he be 20: beyond that period, he directs ten grains to be given for the first day's consumption, gradually increasing the dose according to the effect. If the patient have not two stools daily, he advises magnesia, or the *sulphas potassæ cum sulphure*, to be added to the hemlock mixture. By this method he says the peculiar symptoms of the disease are removed in the space of a week; nothing but a slight cough remaining. The use of hemlock, however, has by no means become universal in consequence of this publication, nor indeed has this remedy been found equally successful with others who have given it a fair trial.

Colica.

The remedy most to be depended upon in this disease is change of air. The patient, as soon as the disease is fully formed, ought to be removed to some other part of the country: but there is no occasion for going to a distant place; a mile or two, or frequently a smaller distance, will be sufficient; and in this new habitation, the frequency of the cough is almost instantly diminished to a most surprising degree. After remaining there for some time, however, the cough will often be observed to become again more frequent, and the other symptoms increased. In this case, another change of air, or even a return to the former habitation, becomes necessary. Manifest benefit has even been derived by changing a patient from one room of a house to another. But although change of air has thus been advantageous, it must also be remarked, that when it has been had recourse to at very early periods it has often done mischief, particularly by aggravating the febrile and inflammatory symptoms. If the disease be attended with fever, bleeding and other antiphlogistic remedies are proper. Dr Buchan recommends an ointment made of equal parts of garlic and hog's lard applied to the soles of the feet; but if it have any effect, it is probably merely as an *emplastrum calidum.* It ought to be put on a rag and applied like a plaster. Opiates may sometimes be useful, but in general are to be avoided. They are chiefly serviceable where the cough is very frequent, with little expectoration. In these cases benefit has sometimes also been derived from sulphuric ether, and sometimes from the tincture of cantharides. An almost instantaneous termination has on some occasions been put to this disease by exciting a high degree of fear, or by inducing another febrile contagion: But the effects of both are too uncertain and too dangerous to be employed in practice.

Genus LVIII. PYROSIS.

The Heart-Burn.

Pyrosis, *Sauv.* gen. 200. *Sag.* 158.
Soda, *Lin.* 47. *Vog.* 154.
Scotis, the Water-Brash.
Pyrosis Suecica, *Sauv.* sp. 4.
Cardialgia sputatoria, *Sauv.* sp. 5.

This disease, whether considered as primary or symptomatic, has already been fully treated under Dyspepsia.

Genus LIX. COLICA.

The Colic.

Colica, *Sauv.* gen. 204. *Lin.* 50. *Vog.* 160. *Sag.* 162. *Junck.* 106.
Colica spasmodica et flatulenta, *Hoffm.* II. 284.
Rachialgia, *Sauv.* gen. 211. *Sag.* 168.
Ileus, *Sauv.* gen. 252. *Vog.* 162. *Sag.* gen. 187.
Iliaca, *Lin.* 185.
Dolor et spasmus iliacus, *Hoffm.* II. 263.
Passio iliaca, *Junck.* 107.

Sp. I. *The Spasmodic* Colic.

Colica flatulenta, pituitosa, *Sauv.* sp. 1. 2. 5. 6. 7.
Ileus

Spasmi. Ileus physodes, volvulus inflammatorius, &c. *Ejusd.* sp. 1. 3. 5. 7. 8. 9.

Description. The colic is chiefly known by a violent pain in the abdomen, commonly about the umbilical region. The pain resembles various kinds of sensations, as of burning, twisting, boring, a ligature drawn very tight, &c. The belly is generally costive, though sometimes there is a violent evacuation of bilious matters upwards and downwards. In these cases the disease is sometimes accompanied from the beginning with a weak and intermitting pulse, cold sweats, and fainting. In some the disease comes on gradually, beginning with an habitual costiveness; and if purgatives be taken, they do not operate. The pain comes on generally after a meal, and soon occasions nausea and vomiting. Sometimes the disease is attended with pyrexia, violent thirst, and a full pulse; the vomiting becomes more violent, and excrementitious matters are thrown up with the most exquisite pain and tension of the abdomen; and hiccough comes on, which continues obstinately; till at last a cessation of pain and fetid breath indicate a mortification of the intestines and approaching death. Sometimes the peristaltic motion of the intestines is so totally inverted, that all their contents are evacuated by the mouth, and even clysters will be vomited; which constitutes that disease commonly called the *iliac passion.*

Causes, &c. Colics may arise from any sudden check given to perspiration, as by violent cold applied to any part of the body, especially to the lower extremities and abdomen. Very frequently they are occasioned by austere, acid, or indigestible aliments taken into the stomach. By any of these, a violent colic, or indeed an iliac passion, may be occasioned; for Dr Cullen justly observes, that this last, though commonly accounted a different species of disease, differs from colic in no other way than in being in every respect in a much higher degree. In those who have died of this disease and been dissected, the intestines have sometimes been found twisted; but more commonly there hath been an *introsusception* of the intestine, that is, one part of the gut seems to have entered within the other. In the Edinburgh Medical Essays, vol. iii. we have a dissertation on the use of the warm bath in the bilious colic, in which the author derives the disorder from a spasmodic constriction of the intestine occasioned by the acrimony of the bile. By this, he says, the intestine is not only contracted into an unusual narrowness, but the sides of it have been found, upon dissection, so closely joined, that no passage could be made downwards more than if they had been strongly tied by a ligature. The formation of the *introsusceptio* he explains by quoting a passage from Peyerus, who made the following experiment on a frog. Having irritated the intestine of the animal in several different places, he observed it to contract at those places most violently, and to protrude its contents upwards and downwards wherever the relaxed state of the part would permit; by which means the contents were heaped together in different parts. Hence some parts of the intestine being dilated much more than enough, by reason of the great quantity of matter thrown into them, formed a kind of sack which readily received the constricted part into it. If this happen in the human body, there is the greatest danger of a mortification; because the part which is constricted, and at any rate disposed to inflammation, has that disposition very much increased by its confinement within the other, and by the pressure of the contents of the alimentary canal from the stomach downwards upon it. An iliac passion may also arise from the strangulation of part of the intestine in a hernia; and even a very small portion of it thus strangulated may occasion a fatal disease. In the Medical Observations, vol. iv. however, we have an account of an iliac passion arising from a very different cause, which could neither have been suspected nor cured by any other way than the operation of *gastrotomy*, or opening the abdomen of the patient, in order to remove the cause of the disorder. The patient, a woman of about 28 years of age, died after suffering extreme torture for six days. The body being opened, some quantity of a dirty coloured fluid was found in the cavity of the abdomen. The jejunum and ileum were greatly distended with air. A portion of the omentum adhered to the mesentery, near that part where the ileum terminates in the cæcum. From this adhesion, which was close to the spine, there ran a ligamentous cord or process about two inches and a half long, unequally thick, in some places not thicker than a packthread; which by its other extremity adhered to the coats of the ileum, about two inches above the cæcum. This cord formed a circle with the mesentery, large enough to admit a hen's egg to pass through it. The cord had formed a noose (in a manner difficult to be explained), which included a doubling of about two inches of the lower end of the ileum, and was drawn so tight, that it not only put a stop to the passage of every thing through the bowels, and brought on a gangrene of the strangulated part, but it had even cut through all the coats of the intestine on the opposite side to the mesentery, and made an aperture about an inch long. In the Memoirs of the Academy of Surgery are mentioned several similar cases.

Colica.

Prognosis. The colic is never to be reckoned void of danger, as it may unexpectedly terminate in an inflammation and gangrene of the intestines. Those species of it which are attended with purging must be considered as much less dangerous than those in which the vomiting is very violent. The iliac passion, or that attended with the vomiting of feces, is always to be accounted highly dangerous; but if the passage through the intestines be free, even though their peristaltic motion should be inverted, and clysters evacuated by the mouth, there is much more hope of a cure, than when the belly is obstinately costive, and there is some fixed obstruction which seems to bid defiance to all remedies.

Cure. In the cure of the spasmodic colic, the recovery must ultimately depend on producing a resolution of the spasmodic affection. In order to accomplish this, it is in general necessary to evacuate the contents of the intestines, and to remove morbid irritability existing in that part of the system. But in order to preserve the life of the patient from the most imminent hazard, it is still more necessary to prevent and remove those inflammatory affections which often occur in this disease. As the chief danger in colics arises from an inflammation and consequent mortification of the

Spasmi. the intestines, it is essentially necessary, in the first place, to diminish the tendency to a pyrexia, if there should happen to be any. This is accomplished by bleeding, emollient injections, warm bathing, and cooling medicines taken inwardly. Dr Porter strongly recommends the warm bath in those colics attended with violent evacuations of bile. He supposes it to do service by relaxing the constriction of the intestines, and thus preventing or removing the introsusceptio. In the mean time opiates may be given to ease the pain, while every method is tried, by cathartics and glysters of various kinds to procure a stool. In obstinate cases, where stimulating cathartics have proved ineffectual, the milder kinds, such as manna, senna, oleum ricini, &c. will sometimes succeed; but when every thing of this kind fails, recourse must be had to some of the more extraordinary methods. Some have recommended the swallowing of leaden bullets, on a supposition that by their weight they would force through the obstruction; but these seem much more likely to create than to remove an obstruction. It is impossible they can act by their gravity, because the intestines do not lie in a straight line from the pylorus to the anus; and though this were actually the case, we cannot suppose that the weight of a leaden bullet could prove very efficacious in removing either a spasmodic constriction or an obstruction from any other cause. But when we consider not only that the intestines consist of a great multitude of folds, but that their peristaltic motion (by which only the contents are forced through them) is inverted, the futility of this remedy must be evident. It might rather be supposed to aggravate the disease; as the lead, by its pressure, would tend to fix the introsusception more firmly, or perhaps push it still farther on. The same thing may be said of quicksilver: not to mention the pernicious consequences to be apprehended from swallowing large quantities of this mineral, even if it should prove efficacious in relieving the patient for the present. There are, however, some late cases on record, particularly one by Mr William Perry, published in the sixteenth volume of the Edinburgh Medical Commentaries, in which the hydrargyrus, swallowed in great quantities, was attended with the happiest effects, after every other remedy had been tried in vain.

Another method has been proposed, in the Medical Essays, for relieving the miserable patients in this disorder, which in many cases has been known to do service. The patient is to be taken out of bed, and made to walk about on the cold floor of a damp apartment. At the same time, basons of cold water are to be dashed on his feet, legs, and thighs; and this must be continued for an hour or longer, if a stool be not procured before that time, though this will generally be the case much sooner. The exercise does not at all impair the patient's strength, but rather adds to it; and some very remarkable instances are adduced in the 6th volume of the Medical Essays, where this proved effectual after all other medicines had failed. In one person the disease had come on with a habitual costiveness, and he had been for a week tormented with the most violent pain and vomiting. which could be stopped neither by anodynes nor any other medicines, the sharpest clysters being returned unaltered, and all kinds of purgatives thrown up soon after they were swallowed; but by the above-mentioned method, a stool was procured in 35 minutes, and the patient recovered. In some others the costiveness had continued for a much longer time.—Other remedies are, the blowing air into the intestines by means of a bellows, and the injecting clysters of the smoke of tobacco. But neither of these seem very capable of removing the disease. They can affect only the parts below the obstruction; while, to cure the disease, it is necessary that the obstructed parts themselves should be reached by the medicine, and therefore we have not many well-attested instances of their success. In some obstinate cases, however, benefit has certainly been derived from tobacco-smoke injections, and likewise from injections of tepid water to the extent of several pounds. For putting in practice these modes of cure, a particular apparatus has been contrived; and in cases even apparently desperate, neither should be neglected. The cold water gives a general and very considerable shock to the system, checks the perspiration, and thus drives the humours inward upon the intestines, by which they receive a much more effectual stimulus than can be supposed to arise from any kind of clyster. But when all methods have failed, the only chance the patient can have for life is by a manual operation.

Colica.

In those colics which are attended with faintings, &c. from the beginning, and which generally attack hysteric women and other debilitated persons, all kinds of evacuations are pernicious; and the cure is to be attempted by anodynes and cordials, which will seldom fail of success. Even there also, however, it is necessary that the belly should be moved; and for this purpose injections, containing a solution of asafœtida, which operate powerfully as antispasmodics, are preferable to most other modes of cure.

Sp. II. Colica Pictonum. *The Colic of Poictou.* 30

Rachialgia Pictonum, *Sauv.* sp. 1.
Rachialgia metallica, *Sauv.* sp. 3.
Colica Pictonum *Citesii.*

Another cause to which violent colics are frequently to be ascribed, and which often gives occasion to them where it is very little suspected, is lead, or some solution or fume of it, received into the body. To this cause is evidently owing the colics to which plumbers, lead-miners, and smelters of lead are subject. To the same cause, though not so apparent at first sight, are we to ascribe the Devonshire colic, where lead is received into the body dissolved in cyder, the common drink of the inhabitants of that country. This has been proved by experiment; for lead has been extracted from cyder in quantity sufficient to produce pernicious effects on the human body. The colic of Poictou, and what is called the *dry belly-ach* in the West Indies, are of the same nature: for which reason we give the following general description of the symptoms of all these diseases.

The patient is generally first seized with an acute pain at the pit of the stomach, which extends itself down with griping pains to the bowels. Soon after there is a distention, as with wind; and frequent retchings to vomit, without bringing up any thing but small quantities of bile and phlegm. An obstinate costiveness follows, yet sometimes attended with a tenesmus, and

Spasmi. and the bowels seem to the patient as if they were drawn up towards the back; at other times they are drawn into hard lumps, or hard rolls, which are plainly perceptible to the hand on the belly. Sometimes the coats of the intestines seem to be drawn up from the anus and down from the pylorus towards the navel. When a stool is procured by artificial means, as clysters, &c. the feces appear in little hard knots like sheep's dung, called *scybala*, and are in small quantity. There is, however, usually an obstinate costiveness; the urine is discharged in small quantity, frequently with pain and much difficulty. The pulse is generally low, though sometimes a little quickened by the violence of the pain; but inflammatory symptoms very seldom occur. The extremities are often cold, and sometimes the violence of the pain causes cold clammy sweats and fainting. The mind is generally much affected, and the spirits are sunk. The disease is often tedious, especially if improperly treated, insomuch that the patients will continue in this miserable state for twenty or thirty days successively; nay, instances have been known of its continuing for six months. In this case the pains at last become almost intolerable: the patient's breath acquires a strong fetid smell like excrements, from a retention of the feces, and an absorption of the putrid effluvia from them by the lacteals. At last, when the pain in the bowels begins to abate, a pain comes on in the shoulder-joints and adjoining muscles, with an unusual sensation and tingling along the spinal marrow. This soon extends itself from thence to the nerves of the arms and legs, which become weak; and that weakness increases till the extreme parts become paralytic, with a total loss of motion, though a benumbed sensation often remains. Sometimes, by a sudden metastasis, the brain becomes affected, a stupor and delirium come on, and the nervous system is irritated to such a degree as to produce general convulsions, which are frequently followed by death. At other times, the peristaltic motion of the intestines is inverted, and a true iliac passion is produced, which also proves fatal in a short time. Sometimes the paralytic affection of the extremities goes off, and the pain of the bowels returns with its former violence; and on the cessation of the pain in the intestines, the extremities again become paralytic; and thus the pain and palsy will alternate for a very long time.

Cure. Various methods have been attempted for removing this terrible disease. The obstinate costiveness which attends it, made physicians at first exhibit very strong purgatives and stimulating clysters. But these medicines, by increasing the convulsive spasms of the intestines, were found to be pernicious. Balsam of Peru, by its warm aromatic power, was found to succeed much better; and Dr Sydenham accordingly prescribed it in the quantity of 40 drops twice or thrice a-day taken on sugar. This, with gentle purgatives, opiates, and some drops of the hotter essential oils, continued to be the medicine commonly employed in this disease, till a specific was published by Dr Lionel Chalmers of South Carolina. This receipt was purchased by Dr Chalmers from a family where it had long been kept a secret. The only unusual medicine in this receipt, and on which the efficacy of it chiefly if not wholly depends, is sulphate of copper. This must be dissolved in water, in the quantity of one grain to an ounce, and the dose of the solution is a wine-glassful given fasting for nine successive mornings. For the first four or five days this medicine discharges much æruginous bile both ways; but the excretions of this humour lessen by degrees; and before the course be ended, it has little other effect than to cause some degree of squeamishness, or promote a few bilious stools, or perhaps may not move the patient at all. At the time of using this medicine the patients should live upon broth made of lean meat, gruel, or panada: but about the seventh or eighth day, they may be allowed bread and boiled chicken. Here the copper seems to do service by its tonic power; and for the same reason alum, recommended by Dr Percival, most probably cures the disease. He says he has found this very efficacious in obstinate affections of the bowels, and that it generally proves a cure in the slighter cases of the colica pictonum. It was given to the quantity of fifteen grains every fourth, fifth, or sixth hour; and the third dose never failed to mitigate the pain, and sometimes entirely removed it. Among purgative medicines the *oleum recini* is found to be the most efficacious. Mercury also, particularly under the form of calomel, has often been employed with success. And much benefit has been derived from combining the calomel with opium. From this combination there is often obtained, in the first instance, an alleviation of the pain, and afterwards a free discharge by the belly.

Colica.

Sp. III. The Colic from *Costiveness.* 304

Colica stercorea, *Sauv.* sp. 3.
Ileus à fæcibus induratis, *Sauv.* sp. 2.

For the treatment of this species, see above.

Sp. IV. The *Accidental Colic.*

Colica Japonica,—accidentalis,—lactentium,—à veneno, *Sauv.* sp. 10. 14. 18. 20.
Cholera sicca auriginosa, à fungis venenatis, *ejusd.* sp. 2.

When colics arise from acrid poisonous matter taken into the stomach, the only cure is either to evacuate the poison itself by vomiting, or to swallow some other substance which may decompound it, and thus render it inactive. The most common and dangerous substances of this kind are corrosive mercury and arsenic. The former is easily decompounded by alkaline salts; and therefore a solution of lixivial salt, if swallowed before the poison has time to induce a mortification of the bowels, will prove a certain cure. Much more uncertain, however, is the case when arsenic is swallowed, because there is no certain and speedy solvent of that substance yet known. Milk has been recommended as efficacious; and lately a solution of *hepar sulphuris*. The latter may possibly do service; as arsenic unites readily with sulphur, and has its pernicious qualities more obtunded by that than by any other known substance: but indeed, even the solvent powers of this medicine are so weak, that its effects as well as those of others must be very uncertain.

Some kinds of fungi, when swallowed, are apt to produce colics attended with stupor, delirium, and convulsions; and the same sometimes happens from eating a large

large quantity of the shell-fish known by the name of muscles (the MYTILUS). Some of the fungi, doubtless, may have an inherent poisonous quality; but generally they as well as the muscles act on a different principle. Their pernicious effects happen most commonly when they are taken on an empty stomach; and are then supposed to be occasioned by their adhering so close to its coats, that it cannot exert its powers, and the whole system is thrown into the utmost disorder. The malady may therefore be very easily prevented; but when once it has taken place, it cannot be removed till either vomiting be excited, or the stomach has recovered itself in such a manner as to throw off the adhering matter.

305 Sp. V. COLIC of *New-born Infants*, from a *Retention* of the *Meconium*. (*Sauv.* sp. 19.)

This disorder would be prevented were children allowed immediately to suck their mothers, whose milk at first is purgative. But as this is not commonly done, the child is frequently troubled with colics. These, however, may be removed by a few grains of ipecacuanha, or a drop or two of antimonial wine. By these means the stomach is cleansed by vomiting, and the belly is generally loosened; but if this last effect does not happen, some gentle purge will be necessary.

306 Sp. IV. COLIC from a *Callosity* of the *Colon*.

It is often impossible to discover this distemper before the patient's death; and though it should, it does not admit of a cure.

307 Sp. VII. The COLIC from *Intestinal Calculi*. (*Sauv.* sp. 10. 15.)

When certain indigestible bodies, such as cherry-stones, plum-stones, small pieces of bones, &c. are swallowed, they frequently prove the basis of calculi, formed by an accretion of some kind of earthy matter; and being detained in some of the flexures of the intestines, often occasion very violent colics. These calculi do not discover themselves by any peculiar symptoms, nor do they admit of any particular method of cure. In the Medical Essays we have an instance of colics for six years, occasioned by calculi of this kind. The concretions were at last passed by stool; and their passage was procured by causing the patient drink a large quantity of warm water, with a view to promote the evacuation of bile, a redundancy of which was supposed to be the cause of her disorder.

308 GENUS LX. CHOLERA, the CHOLERA MORBUS.

Cholera, *Sauv.* 253. *Lin.* 186. *Vog.* 110. *Sag.* 188. *Hoffm.* II. 165.
Diarrhœa cholerica, *Junck.* 112.

309 Sp. I. The *Spontaneous* CHOLERA, coming on without any manifest cause.

Cholera spontanea, *Sauv.* sp. 1. *Sydenh* sect. iv. cap. 2.
Cholera Indica, *Sauv.* sp. 7.

Sp. II. The *Accidental* CHOLERA, from acrid matter taken inwardly. 31

Cholera crapulosa, *Sauv.* sp. 11.
Cholera à venenis, *Sauv.* sp. 4, 5.

The cholera shows itself by excessive vomiting and purging of bilious matters, with violent pain, inflation and distention of the belly. Sometimes the patients fall into universal convulsions; and sometimes they are affected with violent spasms in particular parts of the body. There is a great thirst, a small and unequal pulse, cold sweats, fainting, coldness of the extremities, and hiccough; and death frequently ensues in twenty-four hours.

In this disease, as a great quantity of bile is deposited in the alimentary canal, particularly in the stomach, the first object is to counteract its influence, and to promote an easy discharge of it. It is next necessary to restrain that increased secretion of bile, by which a fresh deposition in the alimentary canal would otherwise be soon produced. And, in the last place, measures must often be employed to restore a sound condition to the alimentary canal, which is frequently much weakened by the violence of the disease.

On these grounds, the cure of this distemper is effected by giving the patient a large quantity of warm water, or very weak broth, in order to cleanse the stomach of the irritating matter which occasions the disease, and injecting the same by way of clyster, till the pains begin to abate a little. After this, a large dose of laudanum is to be given in some convenient vehicle, and repeated as there is occasion. But if the vomiting and purging have continued for a long time before the physician be called, immediate recourse must be had to the laudanum, because the patient will be too much exhausted to bear any further evacuations. Sometimes the propensity to vomit is so strong, that nothing will be retained, and the laudanum itself thrown up as soon as swallowed. To settle the stomach in these cases, Dr Douglas, in the Medical Essays, recommends a decoction of oat-bread toasted as brown as coffee; and the decoction itself ought to be of the colour of weak coffee. He says he does not remember that this decoction was ever vomited by any of his patients. An infusion of mint leaves, or good simple mint-water is also said to be very efficacious in the same case.

The tincture of opium is sometimes retained when given in conjunction with a portion of the sulphuric acid properly diluted. But when it cannot be retained in a fluid form by the aid of any addition, it will sometimes sit upon the stomach when taken in a solid state.

After the violence of the disease is overcome, the alimentary canal, and the stomach in particular, requires to be braced and strengthened. With this view recourse is often had with advantage to different vegetable bitters, particularly to the use of the colombo root; which, while it strengthens the stomach, is also observed to have a remarkable tendency in allaying a disposition to vomiting, which often remains for a considerable time after the cholera may be said to be overcome.

Genus LXI. DIARRHOEA.

Looseness.

Diarrhœa, *Sauv.* gen. 253. *Lin.* 187. *Vog.* 105. *Sag.* gen. 189. *Junck.* 112.
Hepatirrhœa, *Sauv.* gen. 246.
Cholerica, *Lin.* 190.
Cœliaca, *Sauv.* gen. 255. *Lin.* 189. *Vog.* 109. *Sag.* gen. 199.
Lienteria, *Sauv.* gen. 256. *Lin.* 188. *Sag.* gen. 191. *Vog.* 108.
Pituitaria, et leucorrhois, *Vog.* 111. 112.

2 Sp. I. The *Feculent Diarrhoea.*

Diarrhœa stercorosa et vulgaris, *Sauv.* sp. 1. 2.

This is occasioned by too great a quantity of matter thrown into the alimentary canal; and what is discharged has not the appearance of excrements, but is much whiter, and of a thinner consistence. Voracious people who do not sufficiently chew their food, gormandizers, and even those who stammer in their speech, are said to be liable to this disease. In slighter cases it is removed without any medicine, or by a dose of rhubarb; but where the matters have acquired a putrid taint, the disorder may be much protracted and become dangerous. In this case lenient and antiseptic purgatives are to be made use of, after which the cure is to be completed by astringents.

3 Sp. II. *Bilious Diarrhoea.*

(*Sauv.* sp. 8).

This distemper shows itself by copious stools of a very yellow colour, attended with gripes and heat of the bowels, thirst, bitterness and dryness of the mouth, yellowness of the tongue, and frequently follows an intermitting or bilious fever. When the fever is gone, the diarrhœa is to be removed by acidulated and cooling drinks, with small doses of nitre.

4 Sp. III. The *Mucous Diarrhoea.*

Diarrhœa lactentium, *Sauv.* sp. 19.
Dysenteria Parisiaca, *Sauv.* sp. 3.
Diarrhœa ab hypercatharsi, *Sauv.* sp. 16.
Dysenteria à catharticis, *Sauv.* sp. 12.
Pituitaria, *Vog.* 111.
Leucorrhois, *Vog.* 112.
Diarrhœa pituitosa, *Sauv.* sp. 4.
Cœliaca mucosa, *Sauv.* sp. 3.
Diarrhœa serosa, *Sauv.* sp. 10.
a. Diarrhœa urinosa.

This kind of diarrhœa, besides the matters usually excreted, is attended with a copious dejection of the mucus of the intestines with great pain; while the patient daily pines away, but without any fever.—Persons of all ages are liable to it, and it comes on usually in the winter-time; but is so obstinate, that it will sometimes continue for years. In obstinate loosenesses of this kind, vomits frequently repeated are of the greatest service. It is also very beneficial to keep the body warm, and rub the belly with stimulating ointments; at the same time that astringent clysters, rhubarb, and stomachic medicines, are to be exhibited. Starch clysters are very often efficacious.—Some kinds of looseness are contagious; and Sir John Pringle mentions a soldier who laboured under an obstinate diarrhœa, who infected all those that used the same privy with himself. In the looseness which frequently followed a dysentery, the same author tells us that he began the cure with giving a vomit of ipecacuanha, after which he put the patients on a course of astringents. He used a mixture of three drachms of extract of logwood, dissolved in an ounce and a half of spirit of cinnamon, to which was added seven ounces of common water, and two drachms of tincture of catechu. Of this the patient took two spoonfuls once in four or five hours, and sometimes also an opiate at bed-time. He recommends the same medicine in obstinate diarrhœas of all kinds. A decoction of simarauba bark was also found effectual, when the dysenteric symptoms had gone off. Dr Huck, who used this article in North America, also recommends it in diarrhœas. Two or three ounces of the simarauba are to be boiled in a pound and a half of water to a pound, and the whole quantity taken throughout the day. He began with the weakest decoction; and, when the stomach of the patient could easily bear it, he then ordered the strongest: but at the same time he acknowledges, that, unless the sick found themselves sensibly better within three days from the time they began the medicine, they seldom afterwards received any benefit from it. But when all astringents have failed, Sir John Pringle informs us, he hath known a cure effected by a milk and farinaceous diet; and he thinks in all cases the disorder would be much more easily removed, if the patients could be prevailed on to abstain entirely from spirituous liquors and animal food. If the milk by itself should turn sour on the stomach, a third part of lime-water may be added. In one case he found a patient receive more benefit from good butter-milk than from sweet-milk. The chief drinks are decoctions of barley, rice, calcined hartshorn, toast and water, or milk and water.

Sp. IV. The *Coeliac Passion.* 315

Cœlica chylosa, *Sauv.* sp. 1.
Cœlica lactea, *Sauv.* sp. 4.

There are very great differences among physicians concerning the nature of this disease. Sauvages says, from Aretæus, it is a chronic flux, in which the aliment is discharged half digested. It is attended with great pains of the stomach, resembling the prickling of pins; rumbling and flatus in the intestines; white stools, because deprived of bile, while the patient becomes weak and lean. The disease is tedious, periodical, and difficult to be cured. Sauvages adds, that none of the moderns seem to have observed the disease properly; that the excrements indeed are white, on account of a deficiency of the bile, but the belly is bound as in the jaundice. Dr Cullen says there is a dejection of a milky liquid of the nature of chyle; but this is treated by Vogel as a vulgar error. He accuses the moderns of copying from Aretæus, who mentions white fæces as a symptom of the distemper; from whence authors have readily fallen into the notion that they never appeared of any other colour in persons

persons labouring under the cœliac passion. This error quickly produced another, which has been very generally received; namely, that the chyle was thrown out of the lacteals by reason of some obstruction there, and thus passed along with the excrements; of which he says there is not the least proof, and agrees with Aretæus that the whiteness is only occasioned by the want of bile. He endeavours to prove at length, that the cœliac passion can neither be occasioned by an obstruction of the lacteals, nor of the mesenteric glands; though he owns that such as have died of this disease and were dissected, had obstructions in the mesenteric glands; but he denies that all those in whom such obstructions occur, are subject to the cœliac passion. He considers the distemper as arising from a cachexy of the stomachic and intestinal juices; and directs the cure to be attempted by emetics, purgatives, antiseptics, and tonics, as in other species of diarrhœa.

316 Sp. V. The Lientery.

Lienteria spontanea, *Sauv.* sp. 2.

The lientery, according to Sauvages, differs from the cœliac passion only in being a slighter species of the disease. The aliment passes very quickly through the intestines, with scarce any alteration. The patients do not complain of pain, but are sometimes affected with an intolerable hunger. The cure is to be attempted by stomachics and tonics, especially the Peruvian bark. This disease is most common at the earlier periods of life; and then rhubarb in small quantities, particularly when combined with magnesia, is often productive of the best effects.

317 Sp. VI. The *Hepatic Flux.*

Hepatirrhœa intestinalis, *Sauv.* sp. 2.

The hepatic diarrhœa is by Sauvages described as a flux of bloody serous matter like the washings of flesh, which percolates through the coats of the intestines by means of the anastomosing vessels. It is the cœliac passion of Trillianus; and which, according to Sauvages, rarely, if ever, occurs as a primary disease. It has, however, been observed to follow an inflammation of the liver, and then almost always proves fatal.

318 Genus LXII. DIABETES.

A profuse Discharge of Urine.

Diabetes, *Sauv.* gen. 263. *Lin.* 197. *Vog.* 115. *Sag.* gen. 199. *Junck.* 99. *Dobson*, Med. Observat. vol. v. p. 298. *Home's* Clinical Experiments, sect. xvi.
Diuresis, *Vog.* 114.

319 Sp. I. The Diabetes with *sweet Urine.*

Diabetes Anglicus, *Sauv.* sp. 2. *Mead.* on Poisons, Essay I. Ejusdem Monita Med. cap. ix. sect. 2. *Dobson* in Lond. Med. Observ. vol. v. art. 27. *Myers* Diss. inaug. de Diabete, Edinb. 1779.
Diabetes febricosus, *Sauv.* sp. 7. *Sydenh.* Ep. resp. ad R. Brady.

Sp. II. Diabetes with *insipid Urine.*

M. Lister Exerc. Medicin. II. de Diabete. 320
Diabetes legitimus, *Sauv.* sp. 1. *Aretæus* de Morb. diuturn. lib. ii. cap. 2.
Diabetes ex vino, *Sauv.* sp. 5. *Ephem. Germ.* D. I. A. II. Observ. 122.

Description. The diabetes first shows itself by a dryness of the mouth and thirst, white frothy spittle, and the urine in somewhat larger quantity than usual. A heat begins to be perceived in the bowels, which at first is a little pungent, and gradually increases. The thirst continues to augment by degrees, and the patient gradually loses the power of retaining his urine for any length of time. It is remarkable, that though the patients drink much, the quantity of urine always exceeds what is drank. In Dr Home's Clinical Experiments we have an account of two patients labouring under this disease: one of them drank between 10 and 12 English pints a-day without being satisfied. The quantity was greater in the forenoon than in the afternoon. In the other the case was reversed. He drank about four pints a-day, and more in the afternoon than the forenoon. The former discharged from 12 to 15 pints of urine in the day: the latter, 11 or 12; so that his urine always exceeded his drink by eight or at least seven pints. When the urine is retained a little while, there is a swelling of the loins, feet, and scrotum; in this disease the strength gradually decays; the skin is dry and shrivelled; œdematous swellings arise in various parts of the body, but afterwards subside without relieving the disease in the least; and the patient is frequently carried off by convulsions.

The most singular phenomenon in this disease is, that the urine seems to be entirely or very much divested of an animal nature, and to be largely impregnated with a saccharine matter scarce distinguishable from that obtained from the sugar-cane. This discovery was first made by Dr Dobson of Liverpool, who made some experiments on the urine of a person labouring under a diabetes, who discharged 28 pints of urine every day, taking during the same time from 12 to 14 pounds of solid and liquid food. Some of this urine being set aside, fell into a spontaneous effervescence, changed first into a vinous liquor, and afterwards into an acetous one, before it became putrid and offensive. Eight ounces of blood taken from the same patient, separated into crassamentum and serum; the latter being sweet to the taste, but less so than the urine. Two quarts of the urine, evaporated to dryness, left a white cake weighing four ounces two drams and two scruples. This cake was granulated, and broke easily between the fingers: it smelled sweet like brown sugar; neither could it by the taste be distinguished from sugar, except that it left a slight sense of coolness on the tongue. The experiment was repeated after the patient was recovered to such a degree as to pass only 14 pints of urine a-day. There was now a strong urinous smell during the evaporation; and the residuum could not be procured in a solid form; but was blackish, and much resembled very thick treacle. In Dr Home's patients, the serum of the blood had no preternatural sweetness; in one of them the crassamentum was

was covered with a thick inflammatory crust. In one of these patients the urine yielded an ounce and a half, and in the other an ounce, of saccharine matter from each pound. It had, however, an urinous smell, and a saline taste mixed with the sweet one; and the urine of one fermented with yeast, we are told, into "tolerable small-beer." Both these patients had a voracious appetite, and perpetual gnawing sense of hunger; as had also Dr Dobson's patient. The insipid urine of those affected with diabetes has not been examined by physicians with sufficient accuracy to enable us to speak with confidence of its contents.

Causes. These are exceedingly obscure and uncertain; spasms of the nervous system, debility, and every thing inducing it, but especially strong diuretics and immoderate venery, have been accused of bringing on the diabetes. It has, however, occurred in persons where none of these causes could be suspected; nor have the best physicians been able to determine it.—Dissections have only shown that the kidneys were in an enlarged and lax state. In one of Dr Home's patients who died, they smelled sour; which showed that the urine peculiar to diabetes came from the kidneys, and was not sent directly from the intestines by a retrograde motion of the lymphatics, as some imagine.

Prognosis. The diabetes is rarely cured, unless when taken at the very beginning, which is seldom done; and in a confirmed diabetes the prognosis must therefore be unfavourable.

Cure. As there is reason to believe that in this affection the morbid secretion of urine, which is both preternatural in point of quantity and of quality, arises from a morbid diminution of tone in the kidney, the great object in the cure must be the restoration of due tone to the secreting vessels of the kidney. But as even this diminished tone would not give rise to the peculiar vitiated secretion without a morbid sensibility of that organ, it is necessarily a second object to remove this morbid sensibility. But besides this, the morbid secretion of urine may also be counteracted both by a diminution of the determination of fluids to the kidney, and by preventing the occurrence of superfluous water in the general mass of blood.

On these grounds the principal hopes of a cure in this distemper are from astringent and strengthening medicines. Dr Dobson's patient was relieved by the following remedies; which, however, were frequently varied, as none of them produced their good effects for any length of time: Cinchona in substance, with small doses of rhubarb; decoction of the bark, with the acid elixir of vitriol; the cold infusion of the bark, of which he drank from a quart to two quarts daily; Dover's powder; alum-whey; lime-water; antimonials combined with *tinctura thebaica.* The warm bath was used occasionally when the skin was remarkably hot and dry, and the patient complained of restlessness and anxiety. The tincture of cantharides was likewise tried; but he could never take more than 25 drops for a dose, without exciting great uneasiness in his bowels. The body was kept constantly open, either with rhubarb or the infusion of senna joined with rhubarb. His common drinks were rice-water, barley-water, lime-water, and milk; lime-water alone; sage, balm, or mint tea; small beer, simple water, and water acidulated with the sulphuric acid. In seven months, these remedies, in whatever manner varied, made no further progress in removing the disease. In Dr Home's patients, all these medicines, and many others, were tried without the least good effect; insomuch that he uses this remarkable expression: "Thus, these two patients have exhausted all that experience had ever recommended, and almost all that theory could suggest; yet in both cases, the disease has resisted all the means of cure used." It is remarkable, that though septics were given to both, in such quantity as evidently to produce a putrescency in the *primæ viæ*, the urine remained unaltered both in quantity and quality.

Diabetes.

But although this disease be frequently in its nature so obstinate as to resist every mode of cure, yet there can be no doubt that particular remedies have succeeded in different cases. Dr Brisbane relates several cases cured by the use of tincture of cantharides: and Dr M'Cormick has related some in the 9th volume of the Edinburgh Medical Commentaries, which yielded to Dover's powder after a variety of other remedies had been tried in vain.

But of all the modes of cure lately proposed, that which has been most celebrated, is the treatment recommended by Dr Rollo of the Royal Artillery. In a valuable work lately published, entitled *Cases of the Diabetes Mellitus*, he has recorded two remarkable examples of the good effects of a peculiar regimen in this disease. He considers diabetes as being a disease not of the kidney but of the alimentary canal, and as arising from the formation of an uncommon quantity of sugar. He therefore strictly forbids the use of every article of diet which can furnish sugar, even of bread; and by a diet consisting entirely of animal and alkalescent food his patients were much benefited. The experience of some other practitioners has to a certain degree confirmed the observations of Dr Rollo. But we are sorry to add, that we have met with many other instances of diabetes mellitus, in which a diet consisting solely of animal food, had a fair trial, without producing any material benefit. And we may conclude with observing, that the cure of diabetes still remains to be discovered. As allaying the excessive thirst, and producing a temporary restoration of urinous smell, or the urea which it ought naturally to contain, we have found nothing equal in efficacy to a large proportion of fat meat, such as pork steaks or butter.

Genus LXIII. HYSTERIA. 322

Hysterics.

Hysteria, *Sauv.* gen. 135. *Lin.* 126. *Vog.* 219. *Sag.* gen. 242.
Malum hystericum, *Hoffm.* III. 50. *Junck.* 36.
Affectio hysterica, *Willis* de Morb. Convulsiv. cap. 5. 10. 11. *Sydenham* Diss. Epist. ad G. Cole, *Whytt* on Nervous Disorders.

Description. The hysteria is a convulsive disease, which comes on at uncertain intervals, sometimes longer and sometimes shorter, but at no stated time. The paroxysms commonly begin with a languor and debility of the whole body; yawning, stretching, and restlessness A sense of coldness also in the extremities, almost always precedes, and for the most part remains during the whole time of, the paroxysm. To this sometimes

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times succeeds a sense of heat; and the two sensations alternate with each other in different parts of the body. The face is sometimes flushed and sometimes pale: and sometimes the paleness and flushing come alternately. There is a violent pain in the head; the eyes become dim, and pour out tears; there is a rumbling and inflation of the intestines; a sensation is felt like that of a globe ascending from the lower part of the abdomen or hypogastrium, which sometimes seems to roll along the whole alimentary canal. It ascends to the stomach, sometimes suddenly, sometimes slowly; and there produces a sense of inflation and weight, together with anxiety, nausea, and vomiting. At last it comes up to the throat, where it produces a sense of suffocation, and difficulty of breathing or swallowing. During this time there are the most violent pains both in the external and internal parts of the abdomen; the muscles are convulsed; the umbilicus is drawn inwards; and there are frequently such spasms of the intestines, that neither clysters can be injected, nor even flatus pass downwards. Sometimes the paroxysm remits after these symptoms have continued for a certain time, but more frequently the patients fall into fainting fits; sometimes they lie without motion, as if they were in a deep sleep; sometimes they beat their breasts violently and continually with their hands, and sometimes they are seized with general convulsions, and the disease puts on the appearance of an epilepsy. In some patients the extremities become cold and stiff, and the body has the appearance of one in a catalepsy. Sometimes a most violent beating pain takes place in some part of the head, as if a nail was driven into it, and all visible objects seem to turn round; grievous pains attacks the loins, back, and bladder, and the patients discharge a surprising quantity of urine as limpid as water; which last is one of the surest signs of the disease. The mind is very much affected as well as the body. Sometimes the patients are tormented with vain fears: sometimes they will laugh, at other times cry immoderately; and sometimes their temper becomes so peevish and fretful, that they cannot enjoy a moment's quiet. The appearances which take place in this affection are indeed so much varied, that they can hardly be enumerated: they may, however, with propriety, be divided into hysteric fits, which very much resemble those of epilepsy, excepting that they are not attended with an abolition of the internal senses; and hysteric symptoms, such as the *globus hystericus*, *clavus hystericus*, and the like, which are chiefly known to constitute a part of this disease from being observed to alternate with fits.

Causes, &c. The general cause of hysteria is thought by the best physicians to consist in a too great mobility and irritability of the nervous system, and of consequence the disease may be brought on by whatever debilitates and renders the body irritable. Hence it most frequently attacks females of a weak and lax habit of body, though there are some instances of men also attacked by it. It generally comes on between the time of puberty and the age of 35, and makes its attacks during the time of menstruation more frequently than at any other. It also more frequently seizes barren women and young widows, than such as are bearing children.

Prognosis. Though the appearance of this disease be so very terrible, it seldom proves mortal unless by wrong treatment: but notwithstanding this, it is extremely difficult of cure, and rarely admits of any thing else than being palliated; for though it should seem to be conquered by medicine for a time, it very quickly returns, and that from the slightest causes.

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Cure. The ends principally to be aimed at in the cure of this disease are, in the first place, the removal of particular convulsive or spasmodic affections immediately producing various appearances in the disease, whether under the form of proper hysteric fits, or merely of what may be called hysteric symptoms; and in the second place, the prevention of the return of symptoms after they have been removed, by the employment of proper remedies during those intervals from complaints which patients often have when labouring under this affection.

The most powerful remedy hitherto discovered in hysteric cases is opium, or the tincture of it. By this commonly the most violent paroxysms are stopped, though it be insufficient to accomplish a radical cure. In Dr Home's Clinical Experiments we find an instance of a cure performed by venesection, though this remedy has been generally condemned in hysterical cases. Asafœtida seems to stand next in virtue to opium; though with some it disagrees, and occasions pains in the stomach and vomiting. Sulphuric æther will also frequently remove an hysteric fit; but its effects are of short duration; and if it do not effect a cure soon after its exhibition, no service is to be expected either by perseverance in the use of it or by increasing the dose; and with some constitutions it disagrees to such a degree as to occasion convulsions. If the patient be seized with a violent fit, so that she can swallow nothing, which is frequently the case, it will be proper to apply some strong volatile alkali to her nose; or if that be not at hand, the vapour of burning feathers is sometimes very efficacious. In some instances benefit is derived from the sudden application of cold water to the face or hands; but still more frequently the application of water in a tepid state, particularly the warm pediluvium, is found to be of very great service in bringing about a favourable termination of different violent hysteric symptoms. A plaster of galbanum and asafœtida will also prove serviceable: but it must be remembered, that none of these things will prevent the return of the disease; and therefore a radical cure is to be attempted by exercise, cinchona, chalybeates, mineral waters, and other tonics; but particularly, where the state of the patient is such as to be able to bear it, by the use of the cold bath, which, where it does not disagree with the constitution, is often of the greatest service in preventing returns of this affection.

In hysteria as well as in chorea Dr Hamilton has found, that in some instances very great benefit has been obtained from copious evacuations of the alimentary canal, by cathartics frequently repeated.

Genus LXIV. HYDROPHOBIA.

3?

The *Dread* of Water

Hydrophobia, *Sauv.* gen. 231. *Lin.* 86. *Vog.* 30. *Sag.* gen. 343. *Boerh.* 1138. *Junck.* 124. *Mead* on Poisons. *Dessault* sur la rage. *Sauv.* diss. sur la

la rage. *James* on canine madness. *Dalby*, Virtues of cinnabar and musk against the bite of a mad dog. *Nugent* on the hydrophobia. *Choisel*, Nouvelle methode pour le traitement de la rage. *Journal de Medicine*, passim. *Medical Obs. and Inquiries*, vol. iii. art. 34. vol. v. art. 20. 26. and App. *Med. Transact*. vol. ii. art. 5. 12. and 15. *Heysham*, Diss. inaug. de rab. canin. Edinb. 1777. *Parry*, Diss. inaug. de rab. contagios. sive canin. Edinb. 1778. *Andry*, Recherches sur la rage, 1778. *Vaughan*, Cases of hydrophobia, second edit. 1778. *Arnold*, Case of hydrophobia, 1795.

Sp. I. *Hydrophobia Rabiosa*, or Hydrophoby consequent on the *Bite* of a *Mad Animal*.

Hydrophobia vulgaris, *Sauv*. sp. 1.

It is the opinion of some, that Dr Cullen has done wrong in employing the term *hydrophobia* as a generic name, under which canine madness is included: and it must be allowed, that the dread of water, while it is not universal, is also a symptom occurring only late in the disease, at least in the greater part of cases. Perhaps his arrangement would have been less exceptionable, if, following Linnæus, he had adopted *rabies* as a generic term, and had distinguished this particular species by the epithet of *canina*, *contagiosa*, or the like. Disputes, however, about names, are in general not very important; and it is sufficient to observe, that the affection now to be treated of is canine madness, or that disease which arises from the bite of a mad animal.

Description. This disease commonly does not make its attack till a considerable time after the bite. In some few instances it has commenced in seven or eight days from the accident; but generally the patient continues in health for 20, 30, or 40 days, or even much longer. The bite, if not prevented, will in general be healed long before that time, frequently with the greatest ease; though sometimes it resists all kinds of healing applications, and forms a running ulcer which discharges a quantity of matter for many days. It has been said, that the nearer the wounded place is to the salivary glands, the sooner the symptoms of hydrophobia appear. The approach of the disease is known by the cicatrix of the wound becoming high, hard, and elevated, and by a peculiar sense of prickling at the part; pains shoot from it towards the throat: sometimes it is surrounded with livid or red streaks, and seems to be in a state of inflammation; though frequently there is nothing remarkable to be observed about it. The patient becomes melancholy, loves solitude, and has sickness at stomach. Sometimes the peculiar symptom of the disease, *the dread of water*, comes on all at once. We have an instance of one who, having taken a vomit of ipecacuanha for the sickness he felt at his stomach, was seized with the hydrophobia in the time he was drinking the warm water. Sometimes the disease begins like a common sore throat; and the soreness daily increasing, the hydrophobic symptoms show themselves like a convulsive spasm of the muscles of the fauces. In others, the mind seems to be primarily affected, and they are subject to despondency and melancholy for some time prior to any dread of water. And when that dread commences, it is with an evident mental affection. Dr James, in his Treatise on Canine Madness, mentions a boy sent out to fill two bottles with water, who was so terrified by the noise of the liquid running into them, that he fled into the house crying out that he was bewitched. He mentions also the case of a farmer, who, going to draw some ale from a cask, was terrified to such a degree at its running into the vessel, that he ran out in a great haste with the spigot in his hand. But in whatever manner this symptom comes on, it is certain that the most painful sensations accompany every attempt to swallow liquids. Nay, the bare sight of water, of a looking-glass, of any thing clear or pellucid, will give the utmost uneasiness, or even throws the patient into convulsions.

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With regard to the affection of the mind itself in this disease, it does not appear that the patients are deprived of reason. Some have, merely by the dint of resolution, conquered the dread of water, though they never could conquer the convulsive motions which the contact of liquids occasioned: while this resolution has been of no avail; for the convulsions and other symptoms increasing, have almost always destroyed the unhappy patients.

In this disease there seems to be an extreme sensibility and irritability of the nervous system. The eyes cannot bear the light, or the sight of any thing white; the least touch or motion offends them, and they want to be kept as quiet and in as dark a place as possible. Some complain of the coldness of the air, frequently when it is really warm. Others complain of violent heat; and have a great desire for cold air, which yet never fails to increase the symptoms. In all there is a great flow of viscid saliva into the mouth; which is exceedingly troublesome to the patients, as it has the same effect upon their fauces that other liquids have. This therefore they perpetually blow off with violence, which in a patient of Dr Fothergill's occasioned a noise not unlike the hollow barking of a dog, and which he conjectures might have given rise to the common notion that hydrophobous patients bark like dogs. They have an insatiable thirst; but are unable to get down any drink, except with the utmost difficulty; though sometimes they can swallow bread soaked in liquids, slices of oranges, or other fruits. There is a pain under the *scrobiculus cordis*, as in the tetanus; and the patients mournfully point to that place as the seat of the disease. Dr Vaughan is of opinion that it is this pain, rather than any difficulty in swallowing, which distresses the patient on every attempt to drink. The voice is commonly plaintive and mournful; but Dr Vaughan tells us there is a mixture of fierceness and timidity in the countenance which he cannot describe, but by which he could know a hydrophobous person without asking any questions.

In this distemper, indeed, the symptoms are so various, that they cannot be enumerated; for we will seldom read two cases of hydrophobia which do not differ very remarkably in this respect. Some seem to have at times a furious delirium, and an inclination to spit at or bite the bystanders; while others show no such inclination, but will even suffer people to wipe the inside of their mouths with the corner of a handkerchief in order to clear away the viscid saliva which

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The hydrophobia seems to be a symptom peculiar to the human race; for the mad animals which communicate the infection, do not seem to have any dread of water. Dr Wolf, in the letter above quoted, says in general, that cattle bit at the same time and by the same animal (a mad wolf) which bit the persons whoses cases he related, died nearly with the same frightful raging as the men; but says nothing of their having any hydrophobia: nay, Dr James and some others assert, that the hydrophobia is not always an attendant on rabies canina in the human race; and indeed it is certain that the disease has proved mortal after this terrible symptom has been removed. With regard to the symptoms of madness in dogs, they are very equivocal; and those particularly enumerated by some authors, are only such as might be expected in dogs much heated or agitated by being violently pursued and struck. One symptom indeed, if it could be depended upon, would determine the matter; namely, that all other dogs avoid and run away from one that is mad; and even large dogs will not attack one of the smallest size who is infected with this disease. Upon this supposition they point out a method of discovering whether a dog who has been killed was really mad or not; namely, by rubbing a piece of meat along the inside of his mouth, and then offering it to a sound dog. If the latter eats it, it is a sign the dog was not mad; but if the other rejects it with a kind of howling noise, it is certain that he was. Dr James tells us, that among dogs the disease is infectious by staying in the same place; and that after a kennel has been once infected, the dogs put into it will be for a considerable time afterwards in danger of going mad also. A remedy for this, he says, is, to keep geese for some time in the kennel. He rejects as false the opinion that dogs when going mad will not bark; though he owns that there is a very considerable change in their bark, which becomes hoarse and hollow.

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Of all the accounts that have been published on the characteristics of rabies in dogs, the best is to be found in Dr Arnold's late treatise: the characteristics there mentioned are given on the authority of Mr Meynell, a gentleman who has paid particular attention to this subject. From Mr Meynell's observations it appears, that most of the characteristics which have been commonly mentioned, are mere vulgar errors; and, according to him, the best marks are from their peculiar dull look, and the peculiar sound which they utter. "Mad dogs (says Mr Meynell) never bark, but occasionally utter a most dismal and plaintive howl, expressive of extreme distress, and which, they who have once heard it, can never forget; so that dogs may be known to be going mad without being seen, when only this dismal howl is heard.

Causes, &c. In no disease whatever are we more at a loss to discover the causes than in the hydrophobia. In dogs, foxes, and wolves, it seems to come on spontaneously; though this is contested by some authors. It is said, that the causes commonly assigned, viz. heat, feeding upon putrid flesh, want of water, &c. are not sufficient for producing the distemper. It does not appear that madness is more frequent among dogs in the warm than in the cold climates; nay, in the island of Antigua, where the climate is very hot, and the water very scarce, this distemper has never, it is said, been observed. As to putrid aliment, it seems natural for dogs to prefer this to any other, and they have been known to subsist upon it for a long time without any detriment. For these reasons, they think the disease arises from a specific contagion, like the smallpox and measles among the human race, which, being once produced by causes unknown, continues to be propagated by the intercourse which dogs have with each other, as the diseases just mentioned continue to be propagated among the human race.

With regard to the immediate cause among mankind, there is not the least doubt that the hydrophobia is occasioned by the saliva of the mad animal being mixed with the blood. It does not appear that this can operate through the cuticula; but, when that is rubbed off, the smallest quantity is sufficient to communicate

municate the disease, and a slight scratch with the teeth of a mad animal has been found as pernicious as a large wound. It is certain also, that the infection has been communicated by the bites of dogs, cats, wolves, foxes, weasels, swine, and even cocks and hens, when in a state of madness. But it does not appear that the distemper is communicable from one hydrophobous person to another, by means of the bite, or any other way. Dr Vaughan inoculated a dog with the saliva of a hydrophobous child, but the animal continued free from disease for two months: and though the doctor promised to inform the public if it should happen to occur afterwards, nothing has hitherto appeared on that subject. A nurse also frequently kissed this child during the time of his disorder, but no bad consequence ensued.

When we attempt to investigate the nature of the cause of the hydrophobia by dissections, our inquiries are commonly disappointed. In two bodies opened by Dr Vaughan, there was not the least morbid appearance; in the very fauces, where we might have expected that the disease would have shown itself most evidently, there was not the least appearance even of inflammation. The stomach, intestines, diaphragm, œsophagus, &c. were all in a natural state: neither do we find in authors of credit any certain accounts of morbid appearances in the bodies of hydrophobous persons after death. Dr Vaughan therefore concludes, that the poison acts upon the nervous system; and is so wholly confined to it, that it may be doubted whether the qualities of the blood are altered by it or not; and that it acts upon the nerves by impairing and disturbing their functions to such a degree as speedily to end in a total extinction of the vital principle. As to the difficulty in swallowing generally believed to accompany the dread of water, he treats it as a misrepresentation, as well as that the œsophagus with the muscles subservient to deglutition are especially concerned in this disease. The principal foundation of the evil, he thinks, rests on a morbid sensibility both of the external and internal fauces. For the sight of a liquid, or the application of any substance to the internal fauces, but more especially of a fluid, instantly excites the most painful feelings. Nay, the same symptoms are produced by touching the external fauces, with a fluid, or by the contact of cold air with these parts; and nearly in as great a degree. But a solid or fluid substance being conveyed into the œsophagus, the transit into the stomach is accomplished with little or no impediment; so that in fact the difficulty is surmounted before the patient is engaged in the action of swallowing. Nor is the excruciating pain, which never fails to be the companion of every attempt to drink, felt in the *fauces* and *throat*: it is, he says, at the *scrobiculus cordis*; to which the sufferer applies his hand. From this last circumstance, therefore, from the presence of the *risus sardonicus*, from the muscles of the abdomen being forcibly contracted, and from the sense of suffocation which seems to threaten the patient with immediate death, Dr Vaughan has been led to think that in the hydrophobia a new sympathy was established between the fauces, the diaphragm, and the abdominal muscles.

Prognosis. When a person is bit, the prognosis with regard to the ensuing hydrophobia is very uncertain. All those who are bit do not fall into the disease; nay, Dr Vaughan relates, that out of 30 bit by a mad dog, only one was seized with the hydrophobia. During the interval between the bite and the time the disease comes on, there are no symptoms by which we can judge whether it will appear or not. When once it has made its appearance, the prognosis is exceedingly fatal, though there are certainly some well authenticated cases of complete recovery, particularly one recorded by Dr Arnold.

Prevention and Cure. It has been generally allowed by practitioners, that though the hydrophobia may be prevented, yet it can seldom if ever be cured after it has made its appearance. The most essential part of the treatment therefore depends on the proper use of means of prevention. The great objects to be aimed at in prevention, are, in the first place, the complete removal of the contagious matter as soon as possible; or, secondly, means of destroying it at the part, where there is even the slightest reason to believe that it has not been completely removed. Of all the means of removal, the complete cutting out the part to which the tooth had been applied, is unquestionably the most to be depended upon. This practice, therefore, should be had recourse to as soon as possible. The sooner it can be accomplished the better. But it has been observed, that as a peculiar sensation at the part affected always precedes the accession of the disease, even when it takes place at a late period after the bite, there is good ground for believing that the removal of the part may be of advantage even after a considerable interval. But besides removal of the contagious matter, by cutting away the part to which it is attached, this should also be attempted by careful and long-continued washing. This may be done, in most instances, before a proper opportunity can be had of having recourse to the knife. Cold water should particularly be poured upon the wound from a considerable height, that the matter may be washed away with some force. Even after removal by the knife, careful washing is still a necessary and proper precaution. And after both these, to prevent as far as can be the possibility of any contagious matter lurking about the wounded part, it should not be allowed to heal, but a discharge of matter should be supported for the space of several weeks, by ointment with cantharides, or similar applications. By these means there is at least the best chance of removing the matter at a sufficiently early period. And this mode of prevention seems to be of more consequence than all others put together which have hitherto been discovered. But besides removal, prevention may also be obtained by the destruction of the contagious matter at the part; and where there is the least reason to think that a complete removal has not been obtained, this should always be had recourse to. With this intention the actual cautery and burning with gun-powder have been employed. And the action of fire is probably one of the most powerful agents that can be used for this purpose. But recourse has also been had to washing both with acids and with alkalies. Of the former kind, vinegar has been chiefly used, but more may probably be expected from the latter; and particularly from the caustic alkali, so far diluted that it can be applied with safety: for from its influence as a solvent of animal mucus, it gives the

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the best chance of a complete removal of the matter, independent of any influence in changing its nature. It has been thought also, that oil applied to the part may be of service. But if recourse be had to it, more active measures should at least be previously employed; and even then, some are of opinion that it is of advantage to increase the activity of the unctuous matter by combining it with mercury.

On these grounds, and by these means, we are inclined to think that the action of this contagion on the system, after it has been applied by the bite of a rabid animal, may be most effectually prevented. But after this action has once taken place, no remedy has yet been discovered on which much dependence can be put. A very great variety of articles indeed have at different periods been held forth as infallible, both in the prevention and cure of this affection; but their reputation has, perhaps, universally been founded on their being given to people, who, though really bit by a mad dog, were yet not infected with the contagion. And this happily, either from the tooth being cleaned in making the bite, or not being covered with contagious matter, is by no means an unfrequent occurrence. Mankind, however, even from the earliest ages, have never been without some boasted specific, which has been held forth as an infallible remedy for this affection till fatal experience demonstrated the contrary. Dr Boerhaave has given a pretty full catalogue of those specifics from the days of Galen to his own time; and concludes, that no dependence is to be put in any of them. It is now, therefore, altogether unnecessary to take notice of burnt crabs, the hyæna's skin, mithridate with tin, liver of the rabid animal, or a variety of other pretended remedies for this disease, proved by experience to be totally inefficacious. But although no greater confidence is perhaps to be put in specifics of modern date, it will be proper that these should be mentioned.

Bathing in cold water, especially in the sea, and drinking sea-water for a certain time, have been prescribed, and by some accounted a certain preventive. When this was known to fail, a long course of antiphlogistic regimen, violent submersion in water, even to danger of drowning, and keeping the wounded place open with cauteries, were recommended.—To this extreme severity Dr Mead objected; and in his treatise on this subject endeavours to show, that in all ages the greatest success has been reaped from diuretics, for which reason he proposes the following powder: "Take ash-coloured ground-liverwort, half an ounce; black-pepper, two drams: reduce them separately to powder, then mix them together." This powder was first published in the Philosophical Transactions, by Mr Dampier, in whose family it had been kept as a secret for many years. But this medicine which was inserted in former editions of the London and Edinburgh pharmacopœias under the name of *Pulvis Antilyssus*. has long lost its credit.

There is a famous East India medicine, composed of 24 grains of native and as much factitious cinnabar, made into a powder with 16 grains of musk. This is called the *Tonquin* medicine, and must be taken in a tea cupful of arrac or brandy; and it is said to secure the patient for 30 days, at the expiration of which it is to be repeated; but if he has any symptoms of the disease, it must be repeated in three hours, which is said to be sufficient for a cure. The first dose is to be taken as soon after the bite as possible.

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Another celebrated remedy is Palmarius's powder, composed of the leaves of rue, vervain, sage, polypody, wormwood, mint, mugwort, balm, betony, St John's-wort, and lesser centaury. These herbs must be gathered in their prime, dried separately in the shade, and then powdered. The dose is a dram, or a dram and a half, taken every day.

A remedy which might promise to be more efficacious than any of those hitherto mentioned is mercury. This has been recommended in frictions, and to be taken inwardly in the form of calomel and turbith mineral, in order if possible to raise a slight salivation, on which the efficacy was thought to depend. Besides this, venesection, opium, cinchona, and camphor, have been tried in very large quantities; the warm bath; and, in short, every thing which human invention could suggest; but with how little success, can be judged from many well authenticated cases.

Dr Wolf, after detailing a number of interesting cases, makes the following observation.—"Thus we see, that the mercury, the acids, the musk, the feeding on the most famous herbs, the sweating, the *cura antiphlogistica*, &c. are no specifics."

The following case by Dr Raymond of Marseilles shows the inefficacy of mercury even as a *preventive*. —On the 19th of July 1765, Mr Boyer, aged 25, of a bloated cachectic habit, was bit by a mad dog in the inferior part of the leg: the wound extended half way round, bled freely, and was like a great scratch. The patient's legs had been swelled for a considerable time before the accident; and there were also two ulcers in the other leg. Some hours after the accident, the actual cautery was applied to the wound. The doctor was not present at this operation; but the part around the bite was rubbed with mercurial ointment immediately after, and the eschar was dressed with the same ointment. The eschar was separated on the first day, but the dressing was continued till the wound was cicatrised. The second day a bolus of four grains of turbith and eight grains of camphor was exhibited. This procured a considerable evacuation both by vomit and stool, and a spitting also came on. The third day the bitten leg was rubbed with mercurial ointment: in the space of a month the frictions were repeated five times on both legs, three drams of mercurial ointment being used in each friction. During the same time the bolus was five times repeated; and this treatment kept up a slight salivation to the 40th day. The evening of the third day he took the *Tonquin medicine*, called also *Sir George Cobb's powder*, in a bolus; which vomited him briskly. This powder was repeated seven or eight times in the month, generally with the same effect. During the first seven or eight days he got four times, in the morning, a dram of the *anagallis flore puniceo*, fresh gathered and powdered. The 41st day, the turbith bolus was prescribed for the seventh time: he was bathed in the sea, and continued the bathing for two days more. On the 74th he was seized with the distemper; and died on the 76th, seemingly suffocated or strangled, his mouth covered with slaver, and his

his face bloated. He lost his senses not above half a quarter of an hour before his death. The pulse was quiet the whole time.

Another instance is mentioned by the same author, of a pregnant woman bit by the same dog and on the same day with Mr Boyer, who was never seized with the distemper. She was treated in much the same manner with him, and salivated a little more. But she was bit through a shamoy leather shoe, which must necessarily have cleaned the animal's teeth of the poisonous saliva before they reached her skin, and to this we are naturally led to ascribe her safety. One of Dr Wolf's patients also was a pregnant woman, and was not seized with the distemper. Perhaps women in a state of pregnancy may be less liable to this distemper than others; but it is more probable that the contagion was not communicated.

The same author tells us, "there are many examples of the inefficacy of mercurial frictions. A surgeon of Marseilles treated a girl about 12 years of age bit by a mad dog, with mercurial frictions; applying them as in the *lues venerea:* yet she died of the hydrophobia on the 55th day. Her wound was not cauterized."

In the following case all the most powerful remedies were tried.—In the afternoon of the 29th of Aug. 1777, Dr Vaughan was called to a boy of eight years of age labouring under a hydrophobia. He had been bit on the wrist by a cat about a month before; of which the marks remained, but without any ulcer, or even the smallest appearance of inflammation. About the middle of the day before Dr Vaughan saw him, he began to complain of a pain in the part bitten, which ascended up the arm, and affected the temple on that side; soon after which he swallowed liquids with reluctance and difficulty. He was put into the warm bath for three quarters of an hour, during which time he was easier: he had a clyster of five ounces of fresh broth, and 30 drops of laudanum, injected immediately after his coming out of it: a liniment consisting of three drams of strong mercurial ointment with the same quantity of oil of amber, was rubbed upon the shoulders and back; two pills of a grain of flowers of zinc, and half a grain of *cuprum ammoniacum*, were taken every three or four hours; and a medicated atmosphere was prepared for him, by burning gum ammoniac in his room. As these remedies were not attended with any good effect, each dose of pills was ordered to contain two grains of *cuprum ammoniacum*, the same quantity of opium, three grains of flowers of zinc, and ten grains of asafœtida; whilst a solution of that fetid gum, with a dram of laudanum, was administered as a clyster. These pills, though repeated every four hours, afforded not the smallest relief, nor did they show the least action on the frame. At last the doctor resolved to put in practice the desperate remedy mentioned by Van Helmont, of throwing the patient into cold water, and keeping him there till he is almost drowned. With this view a large tub of cold water, well saturated with common salt, was prepared, into which the poor boy was plunged over head and ears, and there held until he ceased to struggle. He was then taken out again, and the same operation repeated until he became so quiet that the doctor was under apprehensions that a total extinction of life would take place. He was then wrapped up in a blanket and put to bed, and he remained more quiet than he had formerly been; but all his former restlessness soon returned, his pulse sunk, and he died about two o'clock in the morning.

Another celebrated antidote against the poison of a mad dog has been known for some years by the name of the *Ormskirk medicine.* The true composition of this is kept a secret by the proprietors: however, it has been analysed, and the following composition published by Dr Heysham as perfectly similar to it in all respects.

"Take half an ounce of chalk, three drams of Armenian bole, 10 grains of alum, one dram of elecampane in powder; mix them all together, and add six drops of oil of anise."

They must certainly be very credulous who can put confidence in such an insignificant medicine as a preservative against the hydrophobia: however, there is a possibility that there may be some unknown ingredient in the genuine powder: for it is difficult to analyse powders after the ingredients are thoroughly mixed together. The efficacy of the medicine therefore must depend on the virtues of that unknown ingredient, if any such there be. The following cases, however, too well determine that it is not *infallible*, as was at first pretended. In all probability, as well as many others, its reputation also is solely rested on its being exhibited in many cases where no contagion was communicated to the person bit, and while of course no disease could take place.

On the 14th of February 1774, Mr Bellamy of Holborn, aged 40, was bit by a cat affected with rabies, which was killed the same morning. The following day he took the celebrated Ormskirk medicine, sold by Hill and Berry in Hill-Street, Berkeley-Square, and conformed in every respect to the directions given by the vender. A servant maid, who was bitten in the leg before her master was bitten, likewise took the same remedy. About the middle of April Mr Bellamy complained of a pain in his right knee, which he supposed to be rheumatic, and which continued and increased till the 7th of June, when he got some pills of calomel, ipecacuanha, and *pil. sapon.* from an apothecary, with Huxham's tincture of the bark in small doses. In six days more he had a titillation in the urethra, a contraction of the scrotum and penis to a degree of pain, and an emission of semen after making water, to which he had frequent calls. The medicines were discontinued; and on the 16th of that month the hydrophobia came on, and Dr Fothergill was called. Six ounces of blood were taken from his arm, and a bolus of a scruple of native cinnabar and half a scruple of musk was given every four hours. The distemper manifestly increased through the day. In the evening a clyster was injected, and several times repeated during the night; he had been put into the warm bath, and two drams of strong mercurial ointment rubbed into his legs and thighs by himself. He was greatly relieved by the warm bath while he continued in it, but the symptoms returned with increased violence in the night. The next day being greatly worse, he was blooded to as great a quantity as he could bear, had the warm bath and clysters repeated, and half an ounce of mercurial ointment rubbed into his thighs and legs. Pills of opium were prescribed, but he did not take them. He died the

Spasmi. the same night, at half an hour after 12. This patient was a man of great resolution, and could in part conquer his aversion at water. He seemed to have totally forgot the accident of the bite: and casually said, that he thought this disorder resembled the hydrophobia, without supposing that he was afflicted with that distemper at the time.—The bite on the girl's leg refused to heal, baffled the art of a young surgeon who attempted to cure it, and continued a running ulcer for a long time. She did not fall into the hydrophobia. Hence Dr Fothergill thinks it probable, that keeping the wounds made by the teeth of mad animals open for a long time, would probably be of service as a preventive; but in some of Dr Wolf's patients these artificial drains appear not to have been attended with success.

On the 16th of November 1773, Thomas Nourse, a strong healthy boy of 14, was admitted into the Leicester infirmary; having been that day month bitten by a mad fox-hound. The wound was a large lacerated one on the cheek, and bled very freely on being inflicted. The day after he was bit he went to the sea, where he was dipped with all the severity usually practised under so disagreeable an operation. The *Ormskirk medicine* was also administered with all due care. It was bought of the person in Leicester who is deputed by the proprietor to sell it for him. A common adhesive plaster was applied to the part after sea-bathing; and in the course of a month, without any further trouble, the wound was healed; excepting a small portion, somewhat more than an inch in length, and in breadth about one-tenth. This yielded no discharge, and was quite in a cicatrizing state. Five days before his admission into the infirmary, he began to complain of a tightness over his temples, and a pain in his head: in two days the hydrophobia began to appear; and at its commencement he complained of a *boiling heat* in his stomach, which was continually ascending to the fauces. The disease was pretty strong when he came to the infirmary. He got a bolus of a scruple of musk with two grains of opium; then a composition of 15 grains of musk, one of turbith mineral, and five grains of opium, was directed to be taken every third hour; an ounce of the stronger mercurial ointment was to be rubbed on the cervical vertebræ and shoulders, and an embrocation of two ounces of laudanum, and half an ounce of *acetum saturninum*, was directed to be applied to the throat. But by this last he was thrown into convulsions, and the same effect followed though his eyes were first covered with a napkin. The embrocation was therefore changed for a plaster of three drams of powdered camphor, half an ounce of opium, and six drams *confectio Damocritis*. By these medicines the disease seemed to be somewhat suspended, but the symptoms returned with violence in the evening. His medicine was repeated at seven; and at eight five grains of opium were exhibited without musk or turbith. At nine, another ounce of mercurial ointment was rubbed upon the shoulders, and half an ounce of laudanum with six ounces of mutton-broth was injected into the intestines, but to no purpose. A larger dose of opium was then given, but with as little effect as the former, and he died the same night.

In the month of September 1774, a farmer, aged 25, was bit by a mad dog, whose teeth made a slight wound in the fore finger of the left hand. He was dipped, as usual, in the sea; and drank the sea-water for some time on the spot, which operated briskly as a purge. He continued well till the 6th of June following, when he first felt a pain in that hand and arm; for which he bathed in a river that evening, supposing that it had been a rheumatic complaint. The next day he was sick; and in the evening was seized with a violent vomiting, which continued all that night and till the middle of the next day, when it was succeeded by the hydrophobia. He was treated with the warm bath; had a purgative clyster injected; and as soon as it had operated, a second was given, consisting of four ounces of oil, and half an ounce of laudanum; half an ounce of strong mercurial ointment was rubbed on the fauces, and the part was afterwards covered with the *cataplasma è cymino*, to which was added an ounce of opium. An embrocation was applied to the region of the stomach with continued friction, consisting of half an ounce of spirit of sal ammoniac, ten drams of olive oil, six drams of oil of amber, and ten drams of laudanum. Two ounces of strong mercurial ointment were rubbed upon the shoulders and back; and as a further means of inducing a ptyalism speedily, he received the smoke of cinnabar into the mouth by throwing a dram of that substance now and then upon a hot iron: he was also directed to take every four hours a bolus of 15 grains of musk, three grains of turbith mineral, and four grains of opium. He was easier while in the warm bath, and during the application of the ointment; but died the same night about two o'clock.

Hydrophobia. Many other instances might be adduced of the inefficacy of this pretended specific: which will, it is hoped, create a due degree of caution in those to whom they who are so unfortunate as to be bit by a mad animal may commit themselves. Another remedy may also be mentioned as having had the reputation of being sometimes successful in this disease; which is chiefly employed in different parts of India, particularly in the territory of Tanjore. The medicine to which we now allude contains indeed several articles which are altogether unknown in our materia medica: but it contains at least one very powerful substance well known to us, viz. arsenic. This medicine, known by the name of the Snake Pills, as being principally employed against the bite of the most venomous snakes, is directed to be prepared in the following manner:

Take white arsenic, of the roots of nelli navi, of nevi visham, of the kernels of the ner valum, of pepper, of quicksilver, each an equal quantity. The quicksilver is to be rubbed with the juice of the wild cotton till the globules are perfectly extinguished. The arsenic being first levigated, the other ingredients, reduced to a powder, are then to be added, and the whole beat together with the juice of the wild cotton to a consistence fit to be divided into pills.

Though these pills are principally used against the bite of the cobra de capello, yet they are said also to be successful in the cure of other venomous bites; and, for the prevention of rabies canina, one is taken every morning for some length of time. Of this remedy European practitioners have, we believe, as yet no experience; and if, in the accounts transmitted by

Semi. Hydrophobia.

by East India practitioners, it cannot be said that we have authentic evidence of its want of success, it can as little be pretended that there is indubitable evidence of its efficacy in any instance; and it is by no means improbable, that it will be found equally ineffieacious with others at one time considered as infallible.

Of the great variety of remedies which have had their day of reputation, there is not one which has not possessed the credit, some time or other, of preventing the noxious effects arising from the bite of a mad dog. A more adequate experience has with all of them discovered the deception. It was above observed, that rabies is by no means the infallible consequence of being bit by a mad animal; and that of between 20 and 30 persons who were bit by the dog which gave the fatal wound to one of Dr Vaughan's patients, not one felt the least ill effect but himself. "In the above number (says the doctor) were some who took the Ormskirk medicine; others went to the salt water; and part of them used no remedy, who yet fared equally well with the most attentive to their injury. The same thing has often happened before; and much merit, I doubt not, has been attributed to the medicine taken, from that celebrated one of *Sir George Cobb* down to the *infallible* one which my good *Lady Bountiful's* receipt-book furnishes."

From all that has been said, the reader will judge how far the hydrophobia is capable of being subdued by any of the medicinal powers which have yet been tried. Some eminent physicians assert that it is totally incurable; and allege that the instances recorded by different authors of its cure have not been the genuine kind, but that which comes on spontaneously, and which is by no means so dangerous. Indeed two of Dr Wolf's patients recovered, where the disease seems to have been perfectly genuine: but in these the poison seemed to vent itself partly on some other place besides the nervous system. In one the blood was evidently infected, as it had an abominable fœtor; and the other had a violent pain and swelling in the belly. In all the others, it seemed to have attacked only the nervous system; which perhaps has not the same ability to throw off any offending matter as the vascular system.

There is, however, a possibility that the prodigious affections of the nerves may arise only from a vitiated state of the gastric juices; for it is well known, that the most terrible convulsions, nay the hydrophobia itself, will arise from an affection of the stomach, without any bite of a mad animal. This seems to be somewhat confirmed from one of Dr Wolf's patients, who, though he vomited more than 50 times, yet still threw up a frothy matter, which was therefore evidently secreted into the stomach, just as a continual vomiting of a bilious matter shows a continual and extraordinary secretion of bile. Dr Wolf himself adopts this hypothesis so far as to say, that perhaps the *serum* may become frothy; but in blood drawn from a vein not the least fault appears either in the serum or crassamentum. He affirms, however, that the duodenum appears to be one of the parts first and principally affected; and as it is not inflamed, it would seem that the affection it sustains must arise from the vitiated state of its juices.

Be this as it will, however, in the hydrophobia, the stomach seems totally, or in a great measure, to lose the power which at other times it possesses. Two grains of *cuprum ammoniacum* were repeatedly given to a child of eight years of age without effect; but this dose would occasion violent vomiting in a strong healthy man. Something or other therefore must have prevented this substance from acting on the nervous coat of the stomach; and this we can only suppose to have been the exceedingly disordered state of the gastric juice, which occasioned such violent irritation through the whole body, that the weaker stimulus of the medicine was entirely lost. It would seem proper therefore to consider the stomach in hydrophobic cases as really containing a poisonous matter, which could not be expelled by vomiting, because it is renewed as fast as evacuated. The indication therefore must be, to change its nature by such medicines as are certainly more powerful than the poison; and this indication will naturally lead us to think of large doses of alkaline salts. These, it is certain, will destroy any animal substance with which they come in contact, and render even the poison of serpents inactive. By exhibiting a few doses of them, larger no doubt than what can be safely done on other occasions, we would be certain to change the state of the stomachic juices; and this might free the patient from those intolerable spasms which always occasion death in such a short time. Dr Wolf seems inclined to think that volatile alkalies were of service; but the above hypothesis would incline us to use rather the fixed kind. At any rate, it seems vain for physicians to trust much to the power of opium, mercury, musk, or cinnabar, either singly or combined in any possible way. Cinchona has also failed, and the most celebrated specifics have been found ineffectual. Alkalies are the next most powerful remedies which the *materia* medica affords, and they cannot be more unsuccessful than the others have generally been.

Another remedy which seems adapted to change the nature of the gastric juices is ardent spirits. In one of Dr Wolf's patients two bottles of brandy seem to have effected a cure. The oil mixed with it was of no efficacy in other cases, and the opium and turbith seem not to have been exhibited till the worst was past. In this case the disease seems to have attacked the vascular as well as the nervous system.

In all the patients the warm bath seems to have been a palliative, and a very powerful one, and as such it ought never to be omitted, though we can by no means trust to it as a radical cure; and the above histories abundantly show, that though the warm bath and opium may palliate for a short time, the cause on which the spasms depend is still going on and increasing, till at last the symptoms become too strong to be palliated even for a moment by any medicine however powerful. At any rate, the above-mentioned hypothesis suggests a new indication, which, if attended to, may perhaps lead to useful discoveries. In cases where putrescent bile is abundantly secreted, columbo root and vegetable acids are recommended to change the nature of the poison which the body is perpetually producing in itself. Where corrosive mercury has been swallowed, alkaline salt is recommended to destroy the poison which nature cannot expel by vomiting; and why

Spasmi. why should not something be attempted to destroy the poison which the stomach seems to secrete in the hydrophobia, and which nature attempts to expel, though in vain, by violent efforts to vomit?

But whatever plan may be pursued in the hopes of curing this dreadful malady after any of the symptoms have made their appearance, we ought, in every instance, to direct our immediate care to *prevention*, as being perhaps the only real ground of hope: And the most certain and efficacious way of preventing the ill consequences, is instantly (if it can be done) to cut out the piece that happens to be bitten. Dr James, indeed, says, that he would have little opinion of cutting or cauterizing, if ten minutes were suffered to elapse from the receiving of the bite before the operation was performed. But in an inaugural dissertation lately published at Edinburgh by Dr Parry, the author is of opinion that excision will be of use a considerable time after the bite is received. He adopts this opinion from what happens in the smallpox, where the blood does not seem to receive the infection till some days after inoculation has been performed. A second inflammation, he tells us, then takes place, and the infection is conveyed into the blood. In like manner, when the hydrophobous infection is about to be conveyed into the blood, according to him, the wound, or its cicatrix, begins again to be inflamed; and it is this second inflammation which does all the mischief. Excision, or the cautery, will therefore be effectual any time between the bite and the second inflammation of the wound. Without implicitly trusting to this doctrine, however, or considering it as in any degree ascertained in what manner the poison diffuses itself, by what marks its progress may be known, or how soon the system may be irremediably tainted with its malignity, it is undoubtedly safest not to lose unnecessarily a moment's time in applying the knife. This, or a dilation of the wound if it be small, Dr Vaughan considers as the only prophylactics that can be depended upon. In the latter case, he directs to fill the wound with gunpowder, and set fire to it; which would produce a laceration of the part, and possibly the action of ignited powder upon the poison may have its use. In all cases, likewise, after these practices have been employed, the wound should be prevented from healing for some length of time.

324 Sp. II. The *Spontaneous* HYDROPHOBIA.

Hydrophobia spontanea, *Sauv.* sp. 2.

This disease very much resembles the former, so that it has undoubtedly been often mistaken for it. It has been known to come on from an inflammation of the stomach, where it was cured by repeated and large bloodletting; in hysteria, where it was cured by opium, musk, or other antispasmodics; and in putrid fevers, where it was cured by evacuating the intestinal canal of the putrid matters by repeated clysters. A very good method of distinguishing the two is, that in the spontaneous hydrophobia the patient is much more delirious than in the genuine species. In the instance mentioned in the Medical Essays of this symptom attending the inflammation of the stomach, the patient *raved in the most extraordinary manner*. Dr Raymond says he remembers a spontaneous hydrophobia *attended with madness*; and in almost all the cases of hydrophobia which are said to have been cured, the patient was very delirious. Dr Nugent's patient was very frequently delirious, and dreaded *dogs* as well as water. In the Medical Transactions a case is communicated by W. Wrightson surgeon in Sedgefield, Durham, of *canine madness* successfully treated. This madness indeed came on after the bite of a dog said to be mad: but it appeared only four days after the accident happened, and was attended with symptoms very unlike any of those above-mentioned; for he suddenly started up in a fit of delirium, and ran out of the house, and after being brought in, caught hold of the hot bars of the grate which held the fire: Whereas, in the true hydrophobia, the patients dread the fire, light, or any thing which makes a strong impression on the senses. It is probable, therefore, that this was only a spontaneous hydrophobia, especially as it readily yielded to venesection, 30 drops of laudanum, and pills of a grain and a half of opium given every three hours, some boluses of musk and cinnabar, &c. while in some of the former cases as much opium was given to a boy as would have deprived of life the strongest healthy man had he swallowed it; and yet this amazing quantity produced scarcely any effect. This patient also dreaded the sight of a dog.

Hydrophobia.

ORDER IV. VESANIÆ. 325

Paranoiæ, *Vog.* Class IX.
Deliria, *Sauv.* Class VIII. Ord. III. *Sag.* Class XI. Ord. III.
Ideales, *Lin.* Class V. Ord. I.

GENUS LXV. AMENTIA. 326

FOLLY, or *Idiotism.*

Amentia, *Sauv.* gen. 233. *Vog.* 337. *Sag.* 346.
Morosis, *Lin.* 106.
Stupiditas, Morosis, Fatuitas, *Vog.* 336.
Amnesia, *Sauv.* gen. 237. *Sag.* 347.
Oblivio, *Lin.* 107. *Vog.* 338.
Memoriæ debilitas, *Junck.* 120.

GENUS LXVI. MELANCHOLIA. 327

MELANCHOLY *Madness.*

Melancholia, *Sauv.* gen. 234. *Lin.* 71. *Vog.* 332. *Sag.* 347. *Boerh.* 1089. *Junck.* 121.
Dæmonomania, *Sauv.* gen. 236. *Sag.* 348.
Dæmonia, *Lin.* 69.
Vesania, *Lin.* 70.
Paraphobia, *Lin.* 75.
Athymia, *Vog.* 329.
Delirium melancholicum, *Hoffm.* III. 251.
Erotomania, *Lin.* 82.
Nostalgia, *Sauv.* gen. 226. *Lin.* 83. *Sag.* 338. *Junck.* 125.
Melancholia nervea, *Cl. Lorry* de melancholia, P. I.

GENUS LXVII. MANIA. 328

RAVING or FURIOUS *Madness.*

Mania, *Sauv.* gen. 235. *Lin.* 68. *Vog.* 331. *Sag.* 349. *Boerh.* 1118. *Junck.* 122. *Battie* on Madness.
Paraphrosyne, *Lin.* 66.

Amentia,

Amentia, *Lin.* 67.
Delirium maniacum, *Hoffm.* III. 251.

Although these distempers may be considered as distinct genera, yet they are so nearly allied, and so readily change into each other, that it sufficiently justifies the treating all of them together.

The distinguishing characteristic of madness, according to Dr Battie, is a *false perception;* and under this general character may be comprehended all kinds of what is called *madness*, from the most silly stupidity and idiotism to the most furious lunacy. Frequently the different kinds of madness are changed into each other by the casual excitement of some passion: thus, an idiot may become furiously mad, by being put in a violent passion; though this does not so often happen as the change of melancholy into the raving madness, and *vice versa*.

It is a very surprising circumstance, that mad people are not only less liable to be seized with infectious disorders than those who are in perfect health; but even when labouring under other diseases, if the patients chance to be seized with madness, they are sometimes freed from their former complaints. Of this kind Dr Mead relates two very remarkable instances.

On the other hand, it has been known, that an intermittent fever, supervening upon madness of long standing, has proved a cure for the madness; the senses having returned when the fever terminated. Dr Monro saw two instances of this himself; and mentions it as an observation made also by his predecessor in the care of Bethlehem hospital.

Another remarkable circumstance is, that immoderate joy, long continued, as effectually disorders the mind as anxiety and grief. For it was observable in the famous South Sea year, when so many immense fortunes were suddenly gained, and as suddenly lost, that more people had their heads turned, from the prodigious flow of unexpected riches, than from the entire loss of their whole substance.

Mad people, especially of the melancholic kind, sometimes obstinately persevere in doing things which must excite great pain; whence it should seem as if their minds were troubled with some distracting notions, which make them patiently bear the present distress, lest more severe tortures should be inflicted; or possibly they may think, that, by thus tormenting the body, they render themselves more acceptable to the divine Being, and expiate the heinous sins of which they may imagine themselves to have been guilty.

It is, however, also highly probable that their feelings differ exceedingly from what they are in a natural state; at least they are every day observed to endure, apparently without the smallest uneasiness, watching, hunger, and cold, to an extent which in a state of health would not only be highly distressing, but to the greater part of individuals would even prove fatal. And this resistance of hunger, cold, and sleep, affords perhaps the best test for distinguishing cases of real insanity, from cases where the disease is only feigned, and appearances of it put on, to answer particular purposes; at least where this power of resistance is present, we have good reason to conclude that the affection is not feigned.

Cure. Although we be well acquainted with many of the remote causes of this disease, some of the principal of which have already been mentioned, yet we are still so ignorant of the influence of these upon the system, as giving a derangement of the mental faculties, that no general principles on which the cure may be conducted, can with any confidence be pointed out.

It may, however, be observed, that while some remedies seem to operate by producing an artificial termination of this complaint, many others have effect only as aiding a natural termination. And where a recovery from this disease does take place, it most frequently happens in consequence of a natural convalescence. All the species and degrees of madness which are hereditary, or that grow up with people from their early youth, are out of the power of physic; and so for the most part, are all maniacal cases of more than one year's standing, from whatever source they may arise. Very often mere debility, the dregs of some particular disease, such as an ague, the small-pox, or a nervous fever, shall occasion different degrees of foolishness or madness. In these cases, the cure must not be attempted by evacuations; but, on the contrary, by nourishing diet, clear air, moderate exercise, and the use of wine: whereas, in almost all the other maniacal cases, which arise from different sources, and which come on in consequence of intemperate living, violent passions, or intense thinking, it is generally held, that evacuations of every kind are necessary, unless the constitution of the patient be such as absolutely forbids them.

Blood is most conveniently drawn either from the arm or jugulars; and if the weakness be such as renders it improper to take away much blood, we may apply cupping-glasses to the occiput.

Vomiting, in weakly people, must be excited by the vinum ipecacuanhæ; but in the more robust by emetic tartar or antimonial wine: the most efficacious cathartics are the infusion or tincture of black hellebore, or infusion of senna quickened with tincture of jalap; but if there be suppression of the menses, or of an habitual hæmorrhoidal discharge, then aloetic purges will be more proper; and in some instances cooling saline purgatives, such as lixiviated tartar, are of great service. In general, mad people require very large doses, both of the emetics and cathartics, before any considerable operation ensues.

Dr Monro assures us, that the evacuation by vomiting is infinitely preferable to any other: the prodigious quantity of phlegm with which the patients in this disease abound, he says, is not to be overcome but by repeated emetics; and he observes, that the purges have not their right effect, or do not operate to so good purpose, until the phlegm be broken and attenuated by frequent emetics. He mentions the case of a gentleman who had laboured under a melancholy for three years, from which he was relieved entirely by the use of vomits and a proper regimen. Increasing the discharge by urine, is also of the greatest moment, especially when any degree of fever is present. The cutaneous discharges are also to be promoted; for which purpose the hot bath is of the highest service in maniacal cases. Hoffman asserts, that he has seen numerous instances, both of inveterate melancholy and raging madness, happily cured by means of warm bathing;

 bleeding

Vesaniæ. bleeding and nitrous medicines having been premised. Camphor has also been highly commended; but, if we can believe Dr Locker of Vienna, not very deservedly. Having found very good effects from a solution of this medicine in vinegar, he took it for granted that all the success was owing to the camphor; therefore, in order to give it a fair trial, he selected seven patients, and gave it in large doses of half a dram twice a-day. This was continued for two months, and the doctor was surprised to find that only one of his patients received any benefit. He then returned the other six back to the camphorated julep made with vinegar, and in a few weeks four of them recovered the use of their reason. This inclined him to think that the virtue depended solely on the vinegar, and accordingly he began to make the trial. Common vinegar was first given: but after a little while he fixed on that which had been distilled, and gave about an ounce and a half of it every day; the patients having been previously prepared by bleeding and purging, which was repeated according as it was found necessary. He gives a list of eight patients who were cured by this method; some in six weeks, others in two months, and none of them took up more than three months in perfecting the cure. He does not indeed give the ages of the patients, nor mention the circumstances of the cases; he only mentions the day on which the use of the vinegar was begun and the day on which they were discharged; and he adds, that they all continued well at the time of his writing.

Dr Locker informs us, that this medicine acts chiefly as a sudorific; and he observed, that the more the patients sweated, the sooner they were cured: it was also found to promote the menstrual discharge in such as had been obstructed, or had too little of this salutary evacuation.

Both reason and experience show the necessity of confining such as are deprived of their senses; and no small share of the management consists in preventing them from hurting either themselves or others. It has sometimes been usual to chain and to beat them: but this is both cruel and absurd; since the contrivance called the *strait waistcoat* answers every purpose of restraining without hurting them.

These waistcoats are made of ticken, or some such strong stuff; are open at the back, and laced on like a pair of stays; the sleeves are made tight, and long enough to cover the ends of the fingers, where they are drawn close with a string like a purse mouth, by which contrivance the patient has no power of his fingers; and when laid on his back in bed, and the arms brought across the chest, and fastened in that position by tying the sleeve-strings round the waist, he has no use of his hands. A broad strap of girth-web is then carried across the breast, and fastened to the bedstead, by which means the patient is confined on his back; and if he should be so outrageous as to require further restraint, the legs are secured by ligatures to the foot of the bed; or they may be secured by being both put into one bag not very wide, which may be more easily fixed than the feet themselves, at least without giving pain.

It is of great use in practice to bear in mind, that all mad people are cowardly, and can be awed even by the menacing look of a very expressive countenance; and when those who have charge of them once impress them with the notion of fear, they easily submit to any thing that is required. The physician, however, should never deceive them in any thing, but more especially with regard to their distemper: for as they are generally conscious of it themselves, they acquire a kind of reverence for those who know it; and by letting them see that he is thoroughly acquainted with their complaint, he may very often gain such an ascendant over them that they will readily follow his directions. Mania.

It is a more difficult matter to manage those whose madness is accompanied either with excessive joy or with great dejection and despondency, than those who are agitated with rage: and all that can be done is to endeavour to excite contrary ideas, by repressing the immoderate fits of laughter in the one kind by chiding or threatening (taking care, however, not absolutely to terrify them, which can never be done without danger, and has often added to the misery of the unhappy sufferer); and dispelling the gloomy thoughts in the other, by introducing pleasing concerts of music, or any other species of entertainment which the patients have been known to delight in while they had the use of their reason. Upon the whole, in the cure of insanity, more is perhaps to be effected by moral than by medical treatment. And this moral treatment should be as gentle as is consistent with safety. Chains, bolts, and severity of every kind are to be avoided as much as possible. But while great benefit is often derived from company and amusement, so also, on the other hand, solitary confinement is in not a few cases productive of the best effects.

Though blistering the head has generally been directed, Dr Mead says he has oftener found it to do harm than service: but he recommends issues in the back; and advises to keep the head always close shaved, and to wash it from time to time with warm vinegar. Opium has by many been forbidden in maniacal cases, from a supposition that it always increases the disturbance; but there are instances where large doses of this medicine have been found to prove a cure, and perhaps if it were tried oftener we should find powerful effects from it: there certainly cannot much harm ensue from a few doses, which may be immediately disused if they should be found to exasperate the disease.

The diet of maniacal patients ought to be perfectly light and thin: their meals should be moderate; but they should never be suffered to live too low, especially while they are under a course of physic: they should be obliged to observe great regularity in their hours: even their amusements should be such as are best suited to their disposition. After the disease appears to be subdued, chalybeate waters and the cold bath will be highly proper to strengthen their whole frame and secure them against a relapse.

Genus LXVIII. ONEIRODYNIA. 329

Uneasiness in Sleep.

Somnium, *Vog.* 339.
Somnambulismus, *Sauv.* gen. 221. *Lin.* 77. *Sag.* 333.
Hypnobatasis, *Vog.* 340.

Noctambulatio,

Marcores.

Noctambulatio, *Junck.* 124.
Ephialtes, *Sauv.* gen. 138. *Lin.* 163. *Sag.* 245.
Incubus, *Vog.* 221. *Junck.* 50.

The greatest uneasiness which people feel in sleep is that commonly called the *incubus* or *night-mare.* Those seized with it seem to have a weight on their breasts and about their præcordia. Sometimes they imagine they see spectres of various kinds which oppress or threaten them with suffocation. Neither does this uneasiness continue only while they are asleep; for it is some time after they awake before they can turn themselves in their beds or speak; nay, sometimes, though rarely, the distemper has proved mortal.—The incubus rarely seizes people except when the stomach is oppressed with aliments of hard digestion, and the patient lies on his back. It is to be cured by eating light suppers, and raising the head high; or, if it become very troublesome, antispasmodic medicines are to be administered, and the body strengthened by chalybeates. The same method is to be followed by those who are subject to walking in their sleep; a practice which must necessarily be attended with the greatest danger. and somnambulism may justly be considered as merely a different modification of this disease. Accordingly Dr Cullen has distinguished the one by the title of *oneirodynia activa,* and the other by that of *oneirodynia gravans.*

Class III. CACHEXIÆ.

Cachexiæ, *Sauv.* Class X. and Class VIII. *Sag.* Class III.
Deformes, *Lin.* Class X.

Order I. MARCORES.

Macies, *Sauv.* Class X. Order I. *Sag.* Class III. Order I.
Emaciantes, *Lin.* Class X. Order I.

Genus LXIX. TABES.

Wasting of the *Body.*

Tabes, *Sauv.* gen. 275. *Lin.* 209. *Vog.* 306. *Sag.* 100.

This disorder is occasioned by the absorption of pus from some ulcer, external or internal, which produces an hectic fever. The primary indication therefore must be to heal the ulcer, and thus take away the cause of the disease. If the ulcer cannot be healed, the patient will certainly die in an emaciated state. But the proper treatment of the tabes proceeding from this cause, falls to be considered under the head of *Ulcer* in Surgery, and likewise under the genera Siphylis, Scrofula, Scorbutus, &c. diseases in which ulcers are at least a very common symptom.

Genus LXX. ATROPHIA.

Nervous Consumption.

Description. This affection consists principally in a wasting of the body, without any remarkable fever, cough, or difficulty of breathing; but attended with want of appetite and a bad digestion, whence the whole body grows languid, and wastes by degrees.—Dr Cullen, however, asserts, that some degree of fever, or at least of increased quickness of the pulse, always attends this disease. Atrophia.

Causes. Sometimes this distemper will come on without any evident cause. Sometimes it will arise from passions of the mind; from an abuse of spirituous liquors; from excessive evacuations, especially of the semen, in which case the distemper has got the name of *tabes dorsalis.* It may arise from mere old age, or from famine.

Prognosis. This distemper, from whatever cause it may arise, is very difficult to cure, and often terminates in a fatal dropsy.

Cure. The general principles on which the treatment of this disease is to be regulated, very much depend on the cause by which it is induced; and it is unnecessary to add, that this must be removed as far as possible. Next to this, the disease is most effectually combated by the introduction of nutritious aliment into the system, and by obtaining the proper assimilation and digestion of this. With the first of these intentions, recourse must be had to the diet which is most nutritious, and at the same time of easiest digestion. But from the condition of the stomach commonly attending this disease, it is necessary that small quantities only should be taken at a time, and that it should be frequently repeated. With the second intention, stomachic and nervous medicines are the articles chiefly at least to be depended upon in this case. The Peruvian bark, sulphuric acid, and chalybeates, are excellent; and these should be conjoined with gentle exercise, as far as the strength and other circumstances of the patient will admit. In that species of the distemper occasioned by venereal excesses, it is so essentially necessary to abstain from them, that without it the best remedies will prove altogether useless.

Order II. INTUMESCENTIÆ. 334

Intumescentiæ, *Sauv.* Class X. Ord. II. *Sag.* Class III. Ord II.
Tumidosi, *Lin.* Class X. Ord. II.

Genus LXXI. POLYSARCIA. 335

Corpulency.

Polysarcia, *Sauv.* gen. 279. *Lin.* 213. *Vog.* 540. *Sag.* 160. Steatites, *Vog.* 390.

In a natural and healthy state, the fat, or animal oil, is not allowed to diffuse itself throughout the cellular interstices at large, but is confined to the places where such an oily fluid is necessary, by a particular apparatus of distinct vesicles. But in some constitutions the oily part of the blood appears to exceed the requisite proportion, and easily separates from the other constituent parts; or there is an uncommon tendency to the separation of oily matter. In these cases it is apt to accumulate in such quantities, that we may suppose it to burst those vesicles which were originally destined to hinder it from spreading too far; or almost every cell of the membrana adiposa, many of which are in ordinary cases altogether empty, may be completely filled and distended with fat.

The increase of the omentum particularly, and the accumulation

Intumescentiæ.

accumulation of fat about the kidneys and mesentery, swell the abdomen, and obstruct the motions of the diaphragm; whence one reason of the difficulty of breathing which is peculiar to corpulent people; while the heart, and the large vessels connected with it, are in like manner so encumbered, that neither the systaltic nor subsultory motion can be performed with sufficient freedom, whence weakness and slowness of the pulse: but when the whole habit is in a manner overwhelmed with an oily fluid, the enlargement of the cellular interstices will necessarily interrupt the general distribution and circulation throughout the nervous and vascular systems; impeding the action of the muscular fibres, and producing insensibility, somnolency, and death.

These cases are the more deplorable, as there is but little prospect of a cure. For the animal oil is of too gross a nature to be easily taken up by absorption; and we know, that when fluids are accumulated in the cellular system, there are only two ways in which they can be carried off or escape; namely, by the absorbents, which take their rise from the cellular interstices, and through the pores of the skin by transudation.

Another misfortune is, that the disease steals on so imperceptibly, that it becomes inveterate before people begin to think of pursuing the proper means of relief.

In this disease the cure must turn upon two points: First, on preventing the farther deposition of fat, by avoiding the introduction of superfluous aliment, particularly of fatty matters, into the system; and, secondly, on promoting and forwarding the absorption of fat. On these grounds, besides what may be done by proper regimen, a variety of articles have been recommended in the way of medicine.

Soap has been proposed as a remedy to melt down and facilitate the absorption of the fat in corpulent people; and Dr Fleming some years ago published a little treatise, wherein he recommends this medicine, and relates the case of a gentleman who is said to have received considerable benefit from it. But perhaps the soap-leys would be more powerful, and might be more easily taken, sheathed in the manner directed when used as a dissolvent of the stone.

Lieutaud advises to take *acetum scilliticum* in small doses, with frequent purging and brisk exercise. But it will seldom happen that the patients will be found sufficiently steady to persist in any of these courses, it being the nature of the disorder to render them irresolute and inattentive to their condition. Therefore the principal use of rules must be with a view to prevention; and persons who are disposed to corpulency should take care in time to prevent it from becoming an absolute disease by using a great deal of exercise, not indulging in sleep, and abridging their meals, especially that of supper. Salted meats are less fattening than such as are fresh; and drinking freely of coffee is recommended to corpulent people.

But Dr Fothergill observes, that a strict adherence to vegetable diet reduces exuberant fat more certainly than any other means that he knows; and gives two cases in which this regimen succeeded remarkably well. The famous Dr Cheyne brought himself down in this way, from a most unwieldy bulk to a reasonable degree of weight; as he himself informs us. It deserves, however, to be remarked, that every practice for the removal or prevention of fatness must be used with great caution and prudence; for not a few, anxious to prevent this affection, have had recourse to a regimen and to medicine which have proved fatal. This has particularly arisen from the excessive use of acids, probably operating by entirely destroying the action of the chylopoietic viscera.

Pneumatosis.

Genus LXXII. PNEUMATOSIS.

Emphysema, or *Windy Swelling*.

Pneumatosis, *Sauv.* gen. 280. *Vog.* 391. *Sag.* 107.
Emphysema, *Sauv.* gen. 13. *Lin.* 288. *Vog.* 392.
Leucophlegmatia, *Lin.* 214.

The emphysema sometimes comes on spontaneously; but more frequently is occasioned by wounds of the lungs, which, giving vent to the air, that fluid insinuates itself into the cellular texture, and often blows it up to a surprising degree. It must be observed, however, that it is only in cases of laceration of the lungs where this disease can take place; for in a simple wound, the effusion of blood always prevents the air from getting out. The cure is to be accomplished by scarifications and compresses; but in some cases only by the paracentesis of the thorax. When air introduced from the lungs is collected in a considerable quantity in the cavity of the thorax, the operation of the paracentesis is perhaps the only means of cure. Upon an opening being thus made, the air sometimes rushes out with incredible violence; and the patient receives at least immediate relief from circumstances the most distressing imaginable. In some instances it is followed even by a complete cure.

Genus LXXIII. TYMPANITES.

Tympany.

Tympanites, *Sauv.* gen. 291. *Lin.* 219. *Vog.* 316. *Sag.* 118. *Boerh.* 226. *Junck.* 87.
Affectio tympanitica, *Hoffm.* III. 339.
Meteorismus, *Sauv.* gen. 292.

This is an inflation of the abdomen, and is of two kinds: 1. That in which the flatus is contained in the intestines, in which the patient has frequent explosions of wind, with a swelling of the belly commonly unequal. 2. When the flatus is contained in the cavity of the abdomen; in which case the swelling is more equal, and the belly sounds when struck, without any considerable emission of flatus. Of these two, however, the former disease is by much the most common; insomuch, that many, even extensively engaged in practice, have never met with an instance of true abdominal tympanites. In both cases the rest of the body falls away.

Causes, &c. The tympany sometimes takes place in those who have been long troubled with flatulencies in the stomach and intestines. It happens frequently to women after abortion; to both sexes after the suppression of the hæmorrhoids; and sometimes from tedious febrile disorders injudiciously treated.

Prognosis. This disease is generally very obstinate, and for the most part proves fatal by degenerating into

Intermittent.

to an ascites. Sometimes, if the patient be healthy and strong, the disease may terminate favourably, and that the more readily if it has followed from some disorder. A hectic consumption, dry cough, and emaciated countenance in a tympany, with a swelling of the feet, denote approaching death in a very short time.

Cure. With a view to the prevention of this affection, it is necessary, in the first place, to avoid, as far as it can be done, causes giving rise to an uncommon extrication of air, by preserving the proper tone of the alimentary canal. After the affection has taken place, the indications are, first, to expel the air already extricated and confined in different cavities; and, secondly, to prevent further accumulation. On these grounds different remedies are employed. The cure, however, is principally attempted by carminative, resolvent, and stomachic medicines, gentle laxatives, and at last tonics, especially chalybeates. In the Edinburgh Medical Essays, vol. i. we have a very remarkable history of a tympany by Dr Monro senior. The patient was a young woman of 22 years of age, who fell into the distemper after a tertian ague, in which she was badly treated. She became a patient in the Edinburgh Infirmary the 24th of March 1730; took several purgatives, and some doses of calomel; used the warm bath; and had an antihysteric plaster applied over the whole belly, but with very little effect. She was monstrously distended, insomuch that the skin seemed to be in danger of bursting: her breathing was much straitened: but the swelling sometimes gradually decreased without any evacuation. The returns and degree of this swelling were very uncertain; and when the belly was most detumefied, several unequal and protuberant balls could be felt over the whole abdomen, but especially at its sides. Her stomach was good, she had no thirst, and her urine was in proportion to the quantity she drank. She was very costive, had her menses at irregular periods, but no œdematous swellings appeared in the feet or any where else. In this situation she continued from the time of her admission till the 21st of June, during which interval she had only menstruated twice. Throughout the space of time, the following circumstances were observed, 1. Several times, upon the falling of the swelling, she complained of a headach; once of pains throughout all her body, once of a giddiness, twice of a nausea and vomiting, and the last time threw up green bile; and once her stomach swelled greatly, whilst the rest of the abdomen subsided. 2. During the flowing of the menses she did not swell, but became very big upon their stopping. 3. Blood-letting and emetics, which were made use of for some accidental urgent symptoms, had no very sensible effect in making the tympany either better or worse. 4. She never had passage of wind either way, except a little belching some days before the monthly evacuation.

Some time before the last eruption of the menses, the purgatives were given more sparingly; and antihysterics of the strongest kinds, such as asafœtida, oleum corn. cerv. &c. mixed with soap, were given in large doses, accompanied with the hotter antiscorbutics as they are called, as horseradish and ginger-root infused in strong-ale with steel. The patient was ordered to use frequent and strong frictions to all the trunk of her body and extremities, and to use moderate exercise. Immediately before the menses began to flow, clysters of the same kind of medicines were injected. The menses were in sufficient quantity; but as soon as they ceased, her belly increased in its circumference four inches and a half, but soon subsided. She then complained of pains, which a gentle sweat carried off. Borborygmi were for the first time observed on the same day, June 25th; and having taken some *tinctura sacra* at night, she passed a small quantity of blood next day by stool. This was the first appearance of the return of the hæmorrhoids, to which she had been formerly subject.

Physometra.

The two following days her saponaceous, antihysteric, and antiscorbutic medicines being still continued, she had such explosions of wind upwards and downwards, that none of the other patients would remain in the same room, nay scarce on the same floor with her. Her belly became less and softer than it had been from the first attack of the disease; her medicines, with a dose of syrup of buckthorn at proper intervals, still were continued, only the proportion of steel was increased; her flatulent discharge went on successfully, and she gradually recovered her former health.

Genus LXXIV. PHYSOMETRA. 338

Windy Swelling of the Uterus.

Physometra, *Sauv.* gen. 290. *Sag.* 119.
Hysterophyse, *Vog.* 317.

The treatment of this is not different from that of the tympany. It is however, upon the whole, a very rare disease; and when it takes place, very seldom if ever admits of a cure.

Genus LXXV. ANASARCA. 339

Watery Swelling over the Whole Body.

Anasarca, *Sauv.* gen. 281. *Lin.* 215. *Vog.* 313. *Sag.* 108. *Boerh.* 1225. *Hoffm.* III. 322. *Junck.* 87. *Monro* on the Dropsy. *Millman* Animadversiones de hydrope 1779.
Phlegmatia, *Sauv.* gen. 282.
Angina aquosa, *Boerh.* 791.

In this disease the feet first begin to swell, especially in the evening, after exercise, and when the patient has stood or sat long; this swelling rises frequently to the thighs. By lying in bed, the swelling becomes less, or even almost disappears. In the progress of the disease, the swelling often rises to the hips, loins, and belly, and at last covers the whole body. This disease, besides the other symptoms afterwards mentioned under Ascites, is attended with a remarkable difficulty of breathing. In the cure of this, as well as other species of dropsy, the general intentions are, first, the evacuation of the water already effused either by natural or artificial outlets: and, secondly, the prevention of fresh accumulation, which is chiefly to be expected from supporting a due action of the absorbents, and from keeping up a proper discharge by the serous excretories.

The remedies employed with these intentions are much the same with what are employed against the more

Intumescentiæ. more important genus of ascites. Only it may be here noticed, that in anasarca it has by many been recommended to scarify the feet and legs. By this means the water is often discharged; but the operator must be cautious not to make the incisions too deep; they ought barely to penetrate through the skin; and special care must be taken, by spirituous fomentations and proper digestives, to prevent a gangrene. Dr Fothergill observes, that the safest and most efficacious way of making these drains is by the instrument used for cupping, called a *scarificator;* and he always orders it to be so applied as to make the little wounds transversely; as they not only discharge better, but are also longer in healing, than when made longitudinally.

Notwithstanding every precaution, however, gangrene will often ensue; and it is upon the whole a much safer practice to evacuate the water by the natural outlets, the valvular lymphatic absorbents; and with this intention emetics and cathartics, but particularly diuretics, are often employed with success.

340 GENUS LXXVI. HYDROCEPHALUS.

WATER in the HEAD.

External or *Chronic* HYDROCEPHALUS.

Hydrocephalus, *Sauv.* gen. 285. *Lin.* 216. *Boerh.* 1217.
Hydrocephalum, *Vog.* 384.

This differs from the hydrocephalus formerly treated of at some length under the title of Apoplexia Hydrocephalica, chiefly in the water being collected in the external parts of the head, whereas the former is entirely within the skull. In the fifth volume of the Medical Observations we have an account of a very extraordinary case of this kind. The patient was a child only of a few days old, and had a tumor on his head about the size of a common tea-cup, which had the appearance of a bladder distended with water; near the apex was a small opening, through which a bloody serum was discharged. In other respects the child was healthy. No application was used but a piece of linen dipt in brandy. The tumor continued to increase for many months; at the end of which time the membrane containing the water appeared equally thick with the other part of the scalp, except at one place about the size of a shilling, which continued thin, and at times appeared as if it would burst. He remained in this situation for about 17 months, when the circumference of the head was 20 inches, the base $16\frac{1}{2}$, the middle $18\frac{1}{2}$, and from the base to the apex near $8\frac{1}{2}$. The water was then drawn off, and the child died in two days. Almost all other cases of this distemper have proved fatal; the sutures of the skull generally give way, and the whole external part of the head is equally enlarged: but in the instance just now given there was a deficiency of part of the bones. Although, however, in some instances, where the head is thus enlarged to an enormous size, the water is exterior to the brain, and therefore entitled to the appellation of hydrocephalus exterior, yet much more frequently in those instances where there is a manifest separation of the bones of the cranium at the sutures, the water is still contained within the ventricles; and accordingly the disease may be much more properly distinguished into the *acute* and *chronic* hydrocephalus, than as is commonly done into the *internal* and *external*. Although the latter be much slower in its progress, sometimes subsisting even for years, yet it is equally difficult of cure with the former, and very often it proves fatal in a few days if the water be drawn off by an artificial opening, which may be very easily performed by a mere puncture with a common lancet, without either pain or any immediate hazard from the operation itself, although the water be lodged in the ventricles; for these are distended to an enormous size, and the substance of the brain almost totally destroyed, so that hardly any thing is to be punctured but membrane.

Hydrorachitis.

GENUS LXXVII. HYDRORACHITIS. 341

SPINA BIFIDA.

Hydrorachitis, *Sauv.* gen. 287. *Morgagn.* de sed. XII. 9. *et seq.*
Spinola, *Lin.* 289.
Spina bifida, *Vog.* 386.

This disease, which consists in a soft tumor on the lumbar vertebræ, attended with a separation of the vertebræ themselves, though generally considered as approaching to the nature of rachitis, is commonly referred to the article SURGERY, which may be consulted with regard to this affection.

GENUS LXXVIII. HYDROTHORAX. 342

DROPSY of the BREAST.

Hydrothorax, *Sauv.* gen. 150. *Vog.* 311. *Boerh.* 1219.

This affection, particularly with respect to its causes, is in many circumstances similar to other kinds of dropsy, particularly to ascites. But from the situation of the water, which is here deposited in the cavity of the thorax, it may naturally be supposed that some peculiar symptoms will occur. Besides the common symptoms of dropsy, paleness of the countenance, scarcity of urine, and the like, this disease is, in some instances, attended with a fluctuation of water within the breast; which, when it does occur, may be considered as a certain distinguishing mark of this affection. But besides this, it is also distinguished by the remarkable affections of circulation and respiration with which it is attended.

The breathing is peculiarly difficult, especially in a recumbent posture; and in many instances patients cannot breathe with tolerable ease, unless when sitting erect, or even stooping somewhat forwards. The pulse is very irregular, and has often remarkable intermissions. But the disease has been thought to be principally characterized by a sudden starting from sleep, in consequence of an almost inexpressible uneasy sensation referred to the breast, and attended with strong palpitation, which may probably arise from an affection either of circulation or of respiration.

That these symptoms are common attendants of this disease, is undeniable; and they are certainly the best characteristics of this affection with which we are yet acquainted: but it must be allowed that they are present in some cases where there is no water in the breast; and

and that in other instances where the disease exists, they are either altogether wanting, or occur only to a very slight degree. Certain diagnostics, therefore, of this disease still remain to be discovered.

When hydrothorax is present, from the affection of the vital functions with which it is attended, it may readily be concluded that it is a dangerous disease, and in many instances it proves fatal. The cure, as far as it can be accomplished, is obtained very much on the same principles as in other dropsies. Here, however, probably from the uncertainty of the diagnostics, the artificial abstraction of water, by paracentesis of the thorax, is less frequently had recourse to than in ascites; though in some instances, after other means have failed, it has been said not only to give relief of symptoms highly urgent, particularly dyspnœa, but even to produce a complete cure. Benefit is often obtained from an artificial discharge of water by the application of blisters to the breast: but in this, as well as other dropsies, a discharge is chiefly effected by the natural outlets, particularly from the use of cathartics and diuretics. In this species of dropsy, more perhaps than in any other, recourse has been had to the use of the digitalis purpurea, or foxglove, so strongly recommended as a diuretic by Dr Withering in his treatise respecting the use of it. There can be no doubt that this article, though sometimes productive of inconvenience from the distressing sickness and severe vomiting which it not unfrequently excites, though used even but in small doses, often operates as a powerful diuretic, and produces a complete evacuation of water, after other articles have failed. From the effects mentioned above, however, as well as from its influence on the pulse, which it renders much slower, it is necessary that it should be employed with great caution, and in small doses. A dram of the dried leaves of the digitalis, macerated for four hours in half a pint of warm water, forms an infusion which may be given in doses of an ounce, and the dried powder of the leaves in doses of one or two grains: these doses may be gradually increased, and repeated twice or oftener in the day; but this requires to be done with great caution, lest severe vomiting, or other distressing symptoms, should take place.

Genus LXXIX. ASCITES.

Dropsy of the Abdomen.

Ascites, *Sauv.* gen. 288. *Lin.* 217. *Vog.* 314. *Sag.* gen. 115. *Boerh.* 1226. *Hoffm.* III. 322. *Junck.* 87. *Dr Monro* on the Dropsy, 1765. *Milman*, Animadversiones de Hydrope, 1779.

Description. This disease assumes three different forms: 1. When the water immediately washes the intestines. 2. When it is interposed between the abdominal muscles and peritonæum. Or, 3. When it is contained in sacs and hollow vesicles: in which case it is called the *encysted dropsy*. Some physicians of great reputation have asserted, that the water was often placed within the duplicature of the peritonæum: but this is alleged by Dr Milman to be a mistake, as that membrane is looked upon by the best anatomists to be single; and he thinks that the above-mentioned physicians have been led into this error from observing the water collected in the cellular substance of the peritonæum.

In the beginning of an ascites the patient becomes languid, breathless, and has an aversion to motion: his belly swells; and, when struck, the sound of fluctuating water is perceptible; there is a difficulty of breathing when the belly is pressed. There is an almost continual thirst, which in the progress of the disease becomes very urgent; the urine is thick, in small quantity, and high coloured. The pulse is small and frequent; and as the belly swells, the other parts waste away. A fever at last arises, which constantly increasing, in the end carries off the patient. These symptoms are most urgent where the waters are in immediate contact with the intestines; in the other kinds the rest of the body is less wasted; nor is there so great thirst or difficulty of breathing.

Causes, &c. The immediate cause of dropsy is a greater effusion of serum by the exhalant arteries than the absorbents take up. This may be occasioned either by too great a quantity of liquid thrown out by the former, or by an inability of the latter to perform their office. This commonly happens in people whose bodies are of a weak and lax texture, and hence women are more subject to this malady than men; chlorotic girls especially are very apt to become dropsical.

Sometimes, however, this disease is occasioned by a debility of the vital powers, by great evacuations of blood, or by acute diseases accidentally protracted beyond their usual period; and although this cause seems very different from a laxity of fibres, yet the dropsy seems to be produced in a similar manner by both. For the vital powers being debilitated by either of these causes, naturally bring on a certain debility and laxity of the solids; and, on the other hand, a debility of the solids always brings on a debility of the vital powers; and from this debility of the vital powers in both cases it happens, that those humours which ought to be expelled from the body are not discharged, but accumulate by degrees in its cavities. There is, however, this difference between the two kinds of dropsy arising from these two different causes: That in the one which arises from laxity, the solid parts are more injured than in that which arises from a debility of the vital powers. In the former, therefore, the water seems to flow out from every quarter, and the body swells all over. But when the disease is occasioned by a debility of the vital powers, though the solids be less diseased, yet the power of the heart being much diminished, and the humours scarce propelled through the extreme vessels, the thin liquids, by which in a healthy state the body is daily recruited, are carried by their own weight either into the cavities or into the cellular texture. Hence those aqueous effusions which follow great evacuations of blood, or violent loosenesses, begin in the more depending parts of the body, gradually ascending, till they arrive at the cavity of the abdomen, or even the thorax.

But another and much more sufficient cause for the production of dropsy is an obstruction of the circulation; and this may take place from polypi in the heart or large vessels, and hard swellings in the abdomen. Instances have been observed of a dropsy arising from steatomatous tumors in the omentum, and many more from a scirrhous liver or spleen, and from an infarction

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tion and obstruction of the mesenteric glands, by which means the lymph coming from the extremities is prevented from arriving at the heart. Scirrhosity of the liver, the most common cause of ascites, probably operates by augmenting effusion, in consequence of its preventing the return of the venous blood, the greater part of the veins from the abdomen going to the formation of the vena portatum.

Lastly, Whatever, either within or without the vessels, contracts or shuts up their cavities, produces a more copious and easy transmission of the thin humours through the exhalant arteries, at the same time that it prevents their return by the absorbent veins. This has been established by experiment: For Lower having perforated the right side of the thorax in a dog, tied the *vena cava*, and sewed up the wound. The animal languished for a few hours, and then died. On dissection, a great quantity of serum was found in the abdomen, as if he had long laboured under an ascites. In like manner, having tied the jugular veins of another dog, a surprising swelling took place in those parts above the ligatures, and in two days the animal died. On dissection, all the muscles and glands were vastly distended, and quite pellucid, with limpid serum. From these experiments, and some cases of the disease mentioned by different authors, it appears, that when the veins are obstructed so that they cannot receive the arterial blood, the serum is separated as by a filtre into the more open cavities and laxer parts of the body, while the thicker part stagnates and is collected in the proper blood-vessels.

The too great tenuity of the humours is very frequently accused as the cause of dropsy, and many authors have asserted that dropsy might arise merely from a superabundance of water in the blood. For this, some experiments are quoted, from which they would infer, that when a great quantity of aqueous fluid is introduced into the blood, the superfluous fluid ought by no means to pass through the extremities of the sanguiferous arteries into the veins in the common course of circulation, but by being effused into the cavities should produce a dropsy. But this can only happen when the vital powers are very much diminished; for, in a natural state, the superfluous quantity is immediately thrown out by the skin or the kidneys: and agreeable to this we have an experiment of Schultzius, who induced a dropsy in a dog by causing him drink a great quantity of water; but he had first bled him almost *ad deliquium*, so that the vital powers were in a manner oppressed by the deluge of water. In this manner do those become hydropic who are seized with the disease on drinking large quantities of water either when wearied with labour, or weakened by some kinds of diseases. Dr Fothergill relates an instance of a person who, being advised to drink plentifully of barley-water, in order to remove a fever, rashly drunk 12 pounds of that liquor every day for a month, and thus fell into an almost incurable dropsy. But if this quantity had been taken only during the prevalence of the fever, he would in all probability, have suffered no inconvenience, as may be inferred from what has been related concerning the *dieta aquea* used by the Italians.

It is moreover evident from experiments, that, in a healthy state, not only water is not deposited in the cavities, but that if it is injected into them it will be absorbed, unless some laxity of the solids has already taken place. Dr Musgrave injected into the right side of the thorax of a dog four ounces of warm water; whence a difficulty of breathing and weakness immediately followed. But these symptoms continually lessened, and in the space of a week the animal seemed to be in as good health as before. Afterwards he injected 16 ounces of warm water into the left cavity of the thorax in the same dog; the same effects followed, together with great heat, and strong pulsation of the heart; but he again recovered in the space of a week. Lastly, He injected 18 ounces of water into one side of the thorax, and only six into the other: the same symptoms followed, but vanished in a much shorter time; for within five days the dog was restored to perfect health. During this time, however, he observed that the dog made a greater quantity of urine than usual.

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The remote causes of dropsy are many and various. Whatever relaxes the solids in such a manner as to give an occasion of accumulation to the serous fluids, disposes to the dropsy. A lazy indolent life, rainy wet weather, a swampy or low soil, and every thing which conduces to vitiate the viscera, or insensibly to produce obstructions in them, paves the way for a dropsy. Hence those are ready to fall into the disease who use hard and viscid aliments, such as poor people in some countries who use coarse brown bread, and children who are fed with unwholesome aliments; and the same thing happens to those who drink immoderately of spirituous liquors.

Prognosis. When the dropsy arises from a scirrhus of the liver or spleen, or any of the other viscera, the prognosis must always be unfavourable, and also when it arises from disorders of the lungs. Neither is the case more favourable to those in whom the small vessels are ruptured, and pour out their liquids into the cavity of the abdomen. Those certainly die who have polypi in the vessels, or tumors compressing the veins and vessels of the abdomen. A dropsy arising from obstructions in the mesenteric glands is likewise difficult to cure, whether such obstructions arise from a bad habit of body, or from any other cause; if we can, however, by any means remove the disease of the glands, the dropsy soon ceases. But in those who fall into dropsy without any disease preceding, it is not quite so dangerous; and even though a disease has preceded, if the patient's strength be not greatly weakened, if the respiration be free, and the person be not affected with any particular pain, we may entertain great hopes of a cure. But where a great loss of blood is followed by a fever, and that by a dropsy, the patients almost always die, and that in a short time: those, however, are very frequently cured who fall into this disease without any preceding hæmorrhage.

Cure. In the cure of this disease authors chiefly mention two indications: 1. To expel the effused water; and, 2. To prevent its being again collected. But before we proceed to speak of the remedies, it is necessary to take notice, that by the laws of the animal economy, if a great evacuation of a fluid takes place in any part of the body, all the other fluids in the body are directed towards that part, and those which lie, as it were, lurking in different parts will be immediately absorbed, and thrown out by the same passage. Hence the humours which in hydropic persons

Cumes- ntiæ. sons are extravasated into the different cavities of the body will be thrown into the intestines, and evacuated by purgatives; or by diuretics will be thrown upon the kidneys, and evacuated by urine. It is, however, not only necessary to excite these evacuations in order to remove this malady, but they must be assiduously promoted and kept up till the abundant humour is totally expelled. For this reason Sydenham has advised purgatives to be administered every day, unless, either through the too great weakness of the body, or the violent operation of the purgative, it shall be necessary to interpose a day or two now and then; because if any considerable intervals be allowed to take place between the exhibition of the purgatives, an opportunity is given to the waters of collecting again. In this method, however, there is the following inconvenience, that, when the waters are totally evacuated, the strength is at the same time so much exhausted, that the distemper commonly returns in a very short time. Hence our chief hopes of curing a dropsy consist in gently evacuating the waters by means of diuretics. But the efficacy of these is generally very doubtful. Dr Freind has long ago observed, that this part of medicine is of all others the most lame and imperfect; but a French physician, Mr Bacher, lately discovered, as he alleges, a method of making the diuretics much more successful. His reputation became at last so great, that the French king thought proper to purchase his secret for a great sum of money. The basis of his medicine was the black hellebore root, the malignant qualities of which he pretended to correct in the following manner: A quantity of the dried roots of black hellebore were pounded, and then put into a glazed earthen vessel, and afterwards sprinkled with spirit of wine. They were suffered to stand for twelve hours, stirring them about twice or thrice during that space of time. They were then sprinkled again, and at last good Rhenish wine was poured on till it stood six fingers above the roots. The mixture was frequently agitated with a wooden spatula; and as the wine was imbibed by the roots, more was poured on, so as to keep it always at the same height for 48 hours. The whole was then put on the fire and boiled for half an hour, after which the decoction was violently pressed out; the same quantity of wine was added as at first, and the mixture boiled as before. After the second expression the woody residuum was thrown away as useless. Both the strained liquors were then mixed together with two parts of boiling water to one of the decoction. The whole is afterwards evaporated in a silver vessel to the consistence of a syrup. One part of the extract is again mixed with two parts of boiling water, and the whole inspissated as before.—By this means, says he, the volatile nauseous acrid particles are separated by evaporation, and the fixed ones remain corrected and prepared for medicinal uses; adding, towards the end, a ninth part of old brandy, and evaporating to the consistence of turpentine. Mr Bacher reasons a good deal on the way in which this process corrects the medicine; but tells us, that notwithstanding the improvement, his pills will not have the desired effect unless properly made up, For forming them, they ought to be mixed with matters both of an inviscating and indurating nature; yet so prepared that it will be readily soluble in the stomach, even of a person much debilitated. For answering these purposes, he chose myrrh and carduus benedictus, and he gives the following receipt for the formation of his pills:—

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"Take of the extract of hellebore prepared as above directed, and of solution of myrrh, each one ounce; of powdered carduus benedictus, three drams and a scruple. Mix them together, and form into a mass, dividing it into pills of a grain and a half each." To these pills Mr Bacher gives the name of the *pilulæ tonicæ*, from an idea, that, while they evacuate the water, they at the same time act as tonics; and thus, from augmenting the action of the lymphatics, prevent the return of the disease. And if both these intentions could be effectually answered by the use of the same remedy, it would unquestionably be of great importance in practice.

The effects of these pills were, we are told, very surprising. Dr Daignan relates that he gave them to eighteen hydropic patients at once; and these he divided into three classes, according to the degree of the disease with which they were affected. The first class contained those who laboured under an anasarca following intermittent fevers. The second class contained those who had an anasarca, together with some degree of ascites, arising from tedious febrile disorders. All these were curod; but these two classes consisted of such cases as are most easily removed. But the third contained six who were seized with a most violent anasarca and ascites, after being much weakened by tedious disorders, and of consequence in whom the disease was very difficult to be cured. Even of these, however, four were cured, and the other two died. The body of one of these being dissected, both sides of the cavity of the thorax were found to be full of a blackish-red water. The lungs were unsound; there was a polypous concretion in the right ventricle of the heart: the liver and spleen were hard, and of a preternatural bulk; and the glands of the mesentery were obstructed and infarcted. In the other, the liver and pancreas were scirrhous, and the spleen very hard.

The same medicines were given by De Horne to eight persons, six of whom had both an anasarca and ascites, but the other two only an ascites. Four of these recovered; three died without being freed from the dropsy; one in whom the dropsy was cured died in a short time after, having for some time before his death become speechless.

By these patients ten of the pills were taken at once; and the same dose repeated to the third time, with an interval of an hour betwixt each dose. At first they proved purgative, and then diuretic: by which last evacuation they finally cured the disease. But though Mr Bacher was firmly of opinion that his pills cured the dropsy by reason of the above-related correction, yet it is certain that, in the hands of other practitioners, these very pills have failed, unless they also made use of the same regimen recommended by that physician; while, on the other hand, it is also certain, that different medicines will prove equally efficacious in dropsical cases, provided this regimen is made use of.

For a great number of ages it has been recommended to dropsical patients to abstain as much as possible from drink, and thus to the torments of their disease was added that of an intolerable thirst; and how great this torment was, we may understand from an example of a friend of King Antigonus, who, having been

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been closely watched both by order of the physicians and also of the king, was so unable to bear the raging thirst occasioned by his disease, that he swallowed his own excrements and urine, and thus speedily put an end to his life. Dr Milman shows at great length the pernicious tendency of this practice. He maintains that it is quite contrary to the sentiments of Hippocrates and the best ancient physicians. He asserts, that unless plenty of diluting drink be given, the best diuretics can have no effect. He condemns also in the strongest terms the practice of giving dropsical patients only dry, hard, and indigestible aliments. These would oppress the stomach even of the most healthy; and how much more must they do so to those who are already debilitated by labouring under a tedious disorder! By what means also are these aliments to be dissolved in the stomach when drink is withheld? In this disease the saliva is viscid, and in small quantity; from whence it may be reasonably conjectured, that the rest of the fluids are of the same nature, and the gastric juices likewise depraved. Thus the aliments lie long in the stomach; and if the viscera were formerly free of obstructions, they are now generated; the strength fails; perspiration and other excretions are obstructed; the viscid and pituitous humours produced by these kinds of food float about the præcordia, and increase the disease, while the surface of the body becomes quite dry. Nay, so much does this kind of diet conspire with the disease, that 100 pounds of fluid will sometimes be imbibed in a few days by hydropic persons who take no drink. Even in health, if the body from any cause becomes dry, or deprived of a considerable part of its juices, as by hunger, labour, &c. it will imbibe a considerable quantity of moisture from the air; so that we must impute the above-mentioned extraordinary inhalation, in part at least, to the denial of drink, and to the nature of the aliment given to the sick. The following is the account given by Sir Francis Milman of his practice in the Middlesex hospital.

If the patient be not very much debilitated, he is sometimes treated with the purging waters, and a dose of jalap and calomel alternately. On the intermediate days he gets a saline mixture, with 40 or 60 drops of *acetum scilliticum* every sixth hour; drinking with the purgatives oat-gruel and some thin broths. That he might the better ascertain what share the liquids given along with the medicines had in producing a copious flow of urine, he sometimes gave the medicines in the beginning of the distemper without allowing the drink: but though the swellings were usually diminished a little by the purgatives, the urine still continued scanty, and the patients were greatly weakened. Fearing, therefore, lest, by following this course, the strength of the sick might be too much reduced, he then began his course of diuretic medicines, giving large quantities of barley water with a little *sal diureticus;* by which means, sometimes in the short space of 48 hours after the course was begun, the urine flowed out in very large quantity: but as saline drinks are very disagreeable to the taste, a drink was composed purposely for hydropic persons, of half an ounce of supertartrite of potash, dissolved in two pounds of barley-water, made agreeably sweet with syrup, adding one or two ounces of French brandy.

To this composition Sir Francis Milman was induced by the great praises given to supertartrite of potash by some physicians in hydropic cases. In the *Acta Bononiensia,* 15 cases of hydropic patients are related who were cured only by taking half an ounce of cream of tartar daily. But it is remarkable, that by these very patients the cream of tartar was taken for 20, 30, nay 40 days, often without any perceptible effect; yet when dissolved in a large quantity of water, it showed its salutary effects frequently within as many hours, by producing a plentiful flow of urine. This liquor is now the common drink of hydropic patients in the hospital above mentioned, of which they drink at pleasure along with their medicines.

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Among purgative medicines Sir Francis Milman recommends the *radix senekæ;* but says the decoction of it, according to the Edinburgh Pharmacopœia is too strong, as he always found it excite vomiting when prepared as there directed, and thus greatly to distress the patients: but when only half an ounce or six drams of the root are used to a pound of decoction, instead of a whole ounce as directed by the Edinburgh college, he finds it an excellent remedy; and though it may sometimes induce a little vomiting, and frequently a nausea, yet it seldom failed to procure nine or ten stools a-day, and sometimes also proved diuretic. But we must take care not to be too free in the use of seneka, or any other purgative, if the patients be very weak; and therefore, after having used purgatives for some time, it will be proper to depend upon diuretics entirely for perfecting the cure; and of the success of this method our author gives some very remarkable instances. But he observes, that after the dropsy is removed, the patients will sometimes die without any evident cause; and of this it is proper that the physicians should be aware. It is remarkable with what ease a flux of urine is induced in those who have a scirrhous liver; while, on the other hand, in one who had the mesenteric glands obstructed, along with a scirrhosity of the liver and vitiated state of the lungs, the most powerful diuretics proved ineffectual. In some cases Sir Francis Milman thinks the kidneys may be so pressed with the weight of the water, as to be unable to perform their office. With regard, however, to diuretics in general, it may be remarked, that the operation of none of them can be certainly depended upon. In particular constitutions, and at particular times, one will be observed to succeed, after another, though commonly much more powerful, has been tried in vain. Accordingly various articles of this kind are often used in succession. Recourse is particularly often had to the root of taraxacum, of colchicum, and of squills; the latter, especially when combined with calomel, is often found to be a very powerful diuretic. And indeed mercury in different forms, probably from acting as a deobstruent, is often of very great use in dropsical complaints. Among other diuretics, the lactuca virosa has of late been highly extolled by Dr Collins of Vienna, and the nicotiana tabaccum by Dr Fowler of York: but neither has been extensively introduced into practice, although we have known some instances in which the latter, in particular, has been used with great advantage.

The water having been drawn off, we are to put the patient on a course of strengtheners; such as cinchona, with some of the warm aromatics, and a due proportion of of rhubarb infused in wine and chalybeates. Gentle exercise, and frictions on the belly, with such a course of diet as shall be light and nourishing, are also to be enjoined; and it may be observed, that the use of tonic medicines is by no means to be delayed till a complete evacuation of the water can be obtained. On the contrary, by alternating, and even combining the use of evacuants and tonics, the influence of both is often very much promoted.

When the patient can by no other means be relieved, the operation of paracentesis must be had recourse to, which is described under the article SURGERY.

344 GENUS LXXX. HYDROMETRA.

DROPSY of the *Uterus.*

Hydrometra, *Sauv.* gen. 289. *Sag.* 116. *Boerh.* 1224.

345 GENUS LXXXI. HYDROCELE.

DROPSY of the *Scrotum.*

Oscheocele, *Sauv.* gen. 41. *Vog.* 388.
Oscheophyma, *Sag.* 44.
Hydrops scroti, *Vog.* 389.
Hydrops testium, *Boerh.* 1227.

For the treatment of these two diseases, we may refer the reader to what has already been said of other species of dropsy, particularly Ascites. But both are chiefly to be combated by chirurgical operation, especially the latter, in which it seldom fails to produce a complete cure.

346 GENUS LXXXII. PHYSCONIA.

SWELLING of the *Belly.*

Physconia, *Sauv.* gen. 283. *Vog.* 325. *Sag.* gen. 110.
Hyposarca, *Lin.* 218.

This disease may arise from a variety of causes, as from a swelling of the liver, spleen, kidneys, uterus, omentum, ovarium, mesentery, intestines, &c. and sometimes it arises merely from fat. In the former cases, as the viscera are generally scirrhous and indurated, the distemper is for the most part incurable; neither is the prospect much better where the disease is occasioned by a great quantity of fat.

347 GENUS LXXXIII. RACHITIS.

The *RICKETS.*

Rachitis, *Sauv.* gen. 294. *Lin.* 212. *Vog.* 312. *Sag.* gen. 120. *Boerh.* 1480. *Hoffm.* III. 487. *Zeviani* della Rachitide. *Glisson* de Rachitide.

Description. This is one of the diseases peculiar to infancy. It seldom attacks children till they are nine months, nor after they are two years old; but it frequently happens in the intermediate space between these two periods. The disease shows itself by a flaccid tumor of the head and face, a loose flabby skin, a swelling of the abdomen, and falling away of the other parts, especially of the muscles. There are protuberances of the epiphyses of the joints; the jugular veins swell, while the rest decrease; and the legs grow crooked. If the child has begun to walk before he be seized with this disease, there is a slowness, debility, and tottering in his motion, which soon brings on a constant desire of sitting, and afterwards of lying down; insomuch that nothing at last is moveable but the neck and head. As they grow older, the head is greatly enlarged, with ample sutures; the thorax is compressed on the sides, and the sternum rises up sharp, while the extremities of the ribs are knotty. The abdomen is protuberant, and the teeth black and carious. In such patients as have died of this disease, all the solids appear soft and flaccid, and the fluids dissolved and mucous.

Causes. The rickets may proceed from scrophulous or venereal taints in the parents, and may be increased by those of the nurse. It is likewise promoted by feeding the child with aqueous and mucous substances, crude summer fruits, fish, unleavened farinaceous aliment, and too great a quantity of sweet things.—Sometimes it follows intermittent fevers and chronic disorders; and in short, is caused by any thing which tends to debilitate the body, and induce a viscid and unhealthy state of the juices.

Prognosis. The rickets do not usually prove fatal by themselves, but if not cured in time, they make the person throughout life deformed in various ways; and often produce very pernicious disorders, such as carious bones in different parts of the body.

Cure. This is to be effected by mild cathartics, alteratives, and tonics, such as are used in other diseases attended with a debility of the system and a vitiated state of the blood and juices. In the Western islands of Scotland, the medicine used for the cure of the rickets is an oil extracted from the liver of the skate-fish. The method of application is as follows: First, the wrists and ankles are rubbed with the oil in the evening: this immediately raises a fever of several hours duration. When the fever from the first rubbing subsides, the same parts are rubbed again the night following; and repeatedly as long as the rubbing of these parts continues to excite the fever.—When no fever can be excited by rubbing the wrists and ankles alone, they are rubbed again along with the knees and elbows. This increased unction brings on the fever again; and is practised as before, till it no longer has that effect. Then the vertebræ and sides are rubbed, along with the former parts; and this unction, which again brings on the fever, is repeated as the former. When no fever can be any longer excited by this unction, a flannel shirt dipped in the oil is put upon the body of the patient: this brings on a more violent and sensible fever than any of the former unctions; and is continued till the cure be completed, which it commonly is in a short time.

A German physician, Dr Strack, has lately published a paper, in which he recommends the filings of iron as a certain remedy in the rickets. This disease, he observes, in general begins with children when they are about 16 months old. It is seldom observed with children before they be one year old, and seldom attacks them after they pass two; and it is very generally worse where it begins early than where it begins late.

For

For effecting a cure, it is, he affirms, a matter of the utmost consequence to be able to distinguish, very early, whether a child will be afflicted with rickets or not. And this, he assures us, may be determined by the following symptoms: Paleness and swelling of the countenance; and in that part of the cheeks which should naturally be red, a yellow colour approaching to that of sulphur. When that is the case, he directs that a medicine should be immediately had recourse to which will retard the further progress of the disease, and remove what has already taken place. For this purpose, he advises that five grains of the filings of iron, and as much rhubarb, should be rubbed up with ten grains of sugar, and given for a dose every morning fasting, and every evening an hour before supper. But if considerable looseness should be produced, it will be necessary, at first, to persist in the use of one dose only every day.

After a month's continuance in this course, according to Dr Strack, there in general ensues a keen appetite for food, quick digestion, and a copious flow of urine; by means of which the fulness of the face and yellowness of the complexion are by degrees removed, while the natural colour of the countenance and firmness of the body in general are gradually restored. This practice, he assures us, has never failed of success in any one instance; not even in those children born of parents greatly afflicted with the rickets.

In addition to the use of chalybeates, great benefit is often also obtained in this disease from the use of the cold bath; which under prudent administration, is perhaps one of the most effectual remedies for this complaint with which we are yet acquainted.

Mr Bonhome of Paris, in a late treatise on the subject of rachitis, has endeavoured to prove, that the disease arises from a peculiar acid, and in the cure he particularly recommends phosphate of soda, phosphate and muriate of lime; but above all other articles alkaline lotions. The efficacy of these remedies, however, is not yet confirmed by experience. And we may conclude with observing, that both in the prevention and cure nothing has been found so successful as cold bathing.

When the bones of rickety children begin to bend, they may sometimes be restored to their natural shape by compresses, bolsters, and proper supports. See the article SURGERY.

348 ORDER III. IMPETIGINES.

Impetigines, *Sauv.* Class X. Ord. V. *Sag.* Class III. Ord. V.

349 GENUS LXXXIV. SCROPHULA.

KING'S EVIL.

Scrophula, *Sauv.* gen. 285. *Vog.* 397. *Sag.* 121. Struma, *Lin.* 284.

Description. This disease shows itself by hard, scirrhous, and often indolent tumors, which arise by degrees in the glands of the neck, under the chin, armpits, and different parts of the body, but most commonly in the neck, and behind the ears. In process of time, the cellular substance, ligaments of the joints, and even the bones themselves, are affected. In scrophula the swellings are much more moveable than those of the scirrhous kind; they are generally softer, and seldom attended with much pain; they are tedious in coming to suppuration; are very apt to disappear suddenly, and again to rise in some other part of the body. We may likewise mention as characteristic circumstances of this disease, a remarkable softness of the skin, a kind of fulness of the face, generally with large eyes, and a very delicate complexion.

Causes. A variety of causes have been mentioned as tending to produce scrophula, viz. a crude indigestible food; bad water; living in damp, low situations; its being an hereditary disease, and in some countries endemic, &c. But whatever may in different circumstances be the exciting or predisposing causes of the scrophula, the disease itself either depends upon, or is at least much connected with, a debility of the constitution in general, and probably of the lymphatic system in particular, the complaint always showing itself by some affections of the latter. And that debility has at least a considerable influence in its production is probable, not only from the manifest nature of some of the causes said to be productive of scrophula, but likewise from such remedies as are found most serviceable in the cure, which are all of a tonic invigorating nature.

Prognosis. The scrophula is a distemper which often eludes the most powerful medicines, and therefore physicians cannot with any certainty promise a cure. It is seldom, however, that it proves mortal in a short time, unless it attacks the internal parts, such as the lungs, where it frequently produces tubercles that bring on a fatal consumption. When it attacks the joints, it frequently produces ulcers, which continue for a long time, and gradually waste the patient; while in the mean time the bones become foul and corroded, and death ensues after a long scene of misery. The prognosis in this respect must be regulated entirely by the nature of the symptoms.

Cure. It was long supposed that scrophula depended upon an acid acrimony of the fluids; and this, it is probable, gave rise to the use of burnt sponge, different kinds of soap, and other alkaline substances, as the best remedies for acidity. But although a sourness of the stomach and *primæ viæ* does no doubt frequently occur in these complaints, yet this symptom seems to be entirely the consequence of that general relaxation which in scrophula so universally prevails, and which does not render it in the least necessary to suppose a general acescency of the fluids to take place; as the one very frequently, it is well known, even in other complaints, occurs without the least suspicion of any acid acrimony existing in the other. This is also rendered very probable from the indolent nature of scrophulous tumors, which have been known to subsist for years without giving any uneasiness; which could not have been the case, if an acid, or any other acrimony, had prevailed in them.

In the treatment of scrophula, different morbid conditions, existing in different parts, require, according to circumstances, various means of cure: but, upon the whole, the remedies directed may be considered as used with a view either to the tumors, to the ulcerations, or to the general state of the system.

Gentle

Scrophula.

Gentle mercurials are sometimes of use as resolvents in scrophulous swellings; but nothing has such considerable influence as a frequent and copious use of cinchona. Cold bathing too, especially in the sea, together with frequent moderate exercise, is often of singular service here; as is likewise change of air, especially to a warm climate.

In the scrophulous inflammation of the eyes, or ophthalmia strumosa, the cinchona has also been given with extraordinary advantage: and we meet with an instance of its having cured the gutta rosacea in the face; a complaint which it is often difficult to remove, and which is extremely disagreeable to the fair sex.

From the various cases related of tumefied glands, it appears, that when the habit is relaxed and the circulation weak, either from constitution or accident, cinchona is a most efficacious medicine, and that it acts as a resolvent and discutient. It will not, however, succeed in all cases; but there are few in which a trial can be attended with much detriment. Dr Fothergill observes, that he has never known it avail much where the bones were affected, nor where the scrophulous tumor was so situated as to be accompanied with much pain, as in the joints, or under the membranous coverings of the muscles; for when the disease attacks those parts, the periostæum seldom escapes without some injury, by which the bone will of course be likewise affected. Here cinchona is of no effect: instead of lessening, it rather increases the fever that accompanies those circumstances: and, if it do not really aggravate the complaint, it seems at least to accelerate the progress of the disease.

Various are the modes in which cinchona is administered: Dr Fothergill makes use of a decoction, with the addition of some aromatic ingredients and a small quantity of liquorice-root, as a form in which a sufficient quantity may be given without exciting disgust. But where it is easily retained in the stomach in substance, perhaps the best form of exhibiting it is that of powder; and in this state it is often advantageously conjoined with powder of cicuta, an article possessing very great deobstruent powers.

The powder, however, soon becomes disagreeable to very young patients; and the extract seems not so much to be depended upon as may have been imagined. In making the extract, it is exposed to so much heat, as must have some effect upon its virtues, perhaps to their detriment. In administering it, likewise, if great care be not taken to mix it intimately with a proper vehicle, or some very soluble substance, in weak bowels it very often purges, and thereby not only disappoints the physician, but injures the patient. A small quantity of the *cortex Winteranus* added gives the medicine a grateful warmth; and a little liquorice, a few raisins, gum arabic or the like, added to the decoction before it be taken from the fire, by making the liquor viscid enables it to suspend more of the fine particles of the bark; by which process the medicine is not only improved in efficacy, but at the same time rendered less disagreeable.

In indolent swellings of the glands from viscid humours, sea-water has been strongly recommended by Dr Russell.

Dr Fothergill also acquaints us, that the cicuta even by itself is not without a considerable share of efficacy in removing scrophulous disorders. He mentions the case of a gentlewoman, about 28 years of age, afflicted from her infancy with scrophulous complaints, severe ophthalmies, glandular swellings, &c. cured by the *extractum cicutæ* taken constantly for the space of a year. He observes, however, that when given to children, even in very small doses, it is apt to produce spasmodic affections; for which reason he rarely exhibits it to them when very young, or even to adults of very irritable habits.

Dr Fothergill gives several other instances of the success of cicuta in scrophulous cases, and even in one which seemed to be not far removed from a confirmed phthisis; but owns that it seldom had such good effects afterwards: yet he is of opinion, that where there are symptoms of tubercles forming, a strumous habit, and a tendency to phthisis, the cicuta will often be serviceable. It is anodyne, corrects acrimony, and promotes the formation of good matter. With regard to the quality of the medicine, he observes, that the extract prepared from hemlock before the plant arrives at maturity, is much inferior to that which is made when the hemlock has acquired its full vigour, and is rather on the verge of decline: just when the flowers fade, the rudiments of the seeds become observable, and the habit of the plant inclines to yellow; this, he thinks, is the proper time to collect the hemlock. It has then had the full benefit of the summer heat; and the plants that grow in exposed places will generally be found more active than those that grow in the shade. The less heat it undergoes during the preparation, the better. Therefore, if a considerable quantity of the dry powder of the plant gathered at a proper season be added, less boiling will be necessary, and the medicine will be the more efficacious. But let the extract be prepared in what manner soever it may, provided it be made from the genuine plant, at a proper season, and be not destroyed by boiling, the chief difference observable in using it is, that a larger quantity of one kind is required to produce a certain effect than of another. Twenty grains of one sort of extract have been found equal in point of efficacy to thirty, nay near forty, of another; yet both of them made from the genuine plant, and most probably prepared with equal fidelity. To prevent the inconveniences arising from this uncertainty, it seems always expedient to begin with small doses, and proceed step by step till the extract produces certain effects, which seldom fail to arise from a full dose. These effects are different in different constitutions. But, for the most part, a giddiness affecting the head, and motions of the eyes, as if something pushed them outwards, are first felt; a slight sickness, and trembling agitation of the body; a laxative stool or two. One or all of these symptoms are the marks of a full dose, let the quantity in weight be what it will. Here we must stop till none of these effects be felt; and in three or four days advance a few grains more. For it has been supposed by most of those who have used this medicine to any good purpose, that the cicuta seldom procures any benefit, though given for a long time, unless in as large a dose as the patient can bear without suffering any of the inconveniences above mentioned. There is however reason to believe, that its effects, as a discutient, are in no degree dependent on its narcotic powers: and

and we are inclined to think, that recourse is often had to larger doses than are necessary; or at least that the same benefit might be derived from smaller ones continued for an equal length of time.

Patients commonly bear a greater quantity of the extract at night than at noon, and at noon than in the morning. Two drams may be divided into thirty pills. Adults begin with two in the morning, two at noon, and three or four at night, with directions to increase each dose, by the addition of a pill to each, as they can bear it.

But, after all, the best form under which the cicuta can, we think, be exhibited, is that of powder from the leaves. This, either under the form of powder or made into pills, may be given at first to the extent of four or five grains, and the dose gradually rising till it amount to 15 or 20 grains twice or thrice a-day. Given to this extent, particularly when conjoined with cinchona, it has often been found of great service in scrophulous cases. At the same time it must be allowed, that such patients, after resisting every mode of cure, will have in some instances a spontaneous recovery in the progress of life, probably from the system acquiring additional vigour.

Different mineral waters, particularly the sulphureous ones, as those of Harrowgate, Moffat, and Gillsland, have been much recommended in scrophula, and sometimes productive of benefit. Recourse has sometimes also been had with advantage to zinc, iron, and barytes, particularly muriate of barytes. But as well as in rachitis, no remedy has been found more efficacious in scrophula than cold bathing, especially sea-bathing.

350 Genus LXXXV. SIPHYLIS.

Lues Venerea, or *French Pox*.

Siphylis, *Sauv.* gen. 3086. *Lin.* 6. *Vog.* 319. *Sag.* 126.

Lues venerea, *Boerh.* 1440. *Hoffm.* III. 413. *Junck.* 96. *Astruc* de Lue Venerea.

Dr Astruc, who writes a very accurate history of the lues venerea, is fully convinced that it is a new disease, which never appeared in Europe till some time between the years 1494 and 1496, having been imported from America by the companions of Christopher Columbus; though this opinion is not without its opponents. Dr Sanches in particular has contended with much learning and ability, that it appeared in Europe at an earlier period: But it is at least certain that it was altogether unknown to the medical practitioners of Greece and Rome, and that it was a very common disease in America when the Europeans first visited that country. But at whatever period it may have been introduced into Europe, or from whatever source it may have been obtained, there can be no doubt that, as well as smallpox or measles, siphylis depends on a peculiar specific contagion; on a matter *sui generis*, which is alone capable of inducing this disease.

The venereal infection, however, cannot, like the contagious miasmata of the smallpox and some other diseases, be carried through the air, and thus spread from place to place: for unless it is transmitted from the parents to the children, there is no other way of

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contracting the disease but from actual contact with the infectious matter. Thus, when a nurse happens to labour under the disease, the infant that she suckles will receive the infection; as, on the other hand, when the child is infected, the nurse is liable to receive it: and there have even been instances known of lying-in women being infected very violently, from having employed a person to draw their breasts who happened to have venereal ulcers in the throat. It may be caught by touching venereal sores, if the cuticle be abraded or torn: and in this way accoucheurs and midwives have sometimes been infected severely. Dr Macbride says, the most inveterate pox he ever saw was caught by a midwife, who happened to have a whitlow on one of her fingers when she delivered a woman ill of the lues venerea.

But by far the most ready way of contracting this disease is by coition, the genital parts being much more bibulous than the rest of the body. When the disorder is communicated, the places where the morbific matter enters are generally those where it first makes its appearance; and as coition is the most usual way of contracting it, so the first symptoms commonly appear on or near the pudenda.

The patient's own account will, for the most part, help us to distinguish the disease: but there are sometimes cases wherein we cannot avail ourselves of this information, and where, instead of confessing, the parties shall conceal all circumstances; while, on the other hand, there are now and then people to be met with, who persuade themselves that symptoms are venereal, which in reality are owing to some other cause: and therefore it is of the utmost importance to inform ourselves thoroughly of the nature of those symptoms and appearances which may be considered as pathognomic signs of lues venerea.

In the first place, when we find that the local symptoms, such as chancres, buboes, phymosis, and the like, do not give way to the usual methods; or when these complaints, after having been cured, break out again without a fresh infection; we may justly suspect that the virus has entered the whole mass of fluids: but if at the same time ulcers break out in the throat, and the face is deformed by callous tubercles, covered with a brown or yellow scab, we may be assured that the case is now become a confirmed lues, which will require a mercurial course.

When eruptions of the furfuraceous and superficial kind are venereal, they are not attended with itching; and the scale being picked off, the skin appears of a reddish brown, or rather copper colour, underneath; whereas leprous eruptions are itchy, throw off a greater quantity of scales, and rise in greater blotches, especially about the joints of the knees and elbows. Venereal tubercles or pustules are easily distinguished from carbuncles of the face, by not occupying the cheeks or the nose, nor as having a purulent apex, but are covered at top, either with a dry branny scurf like the superficial eruptions just now mentioned, or else with a hard dry scab of a tawney yellow hue; they particularly break out among the hair or near to it, on the forehead or on the temples.

Venereal ulcers affecting the mouth are distinguishable from those which are scorbutic, in the following manner: 1. Venereal ulcers first affect the tonsils, fau-

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ces and uvula; then the gums, but these very rarely: on the contrary, scorbutic ulcers affect the gums first of all; then the fauces, tonsils, and uvula. 2. Venereal ulcers frequently spread to the nose; scorbutic ones almost never. 3. Venereal ulcers are callous in the edges; scorbutic ones are not so. 4. Venereal ulcers are circumscribed, and, for the most part, are circular, at least they are confined to certain places; scorbutic ones are of a more regular form, spread wider, and frequently affect the whole mouth. 5. Venereal ulcers are for the most part hollow, and generally covered at bottom with a white or yellow slough; but scorbutic ones are more apt to grow up into loose fungi. 6. Venereal ulcers are red in their circumference, but scorbutic ones are always livid. 7. Venereal ulcers frequently rot the subjacent bones, the scorbutic ones seldom or never. 8. And lastly, Venereal ulcers are generally combined with other symptoms which are known to be venereal; scorbutic ones with the distinguishing signs of the scurvy, such as difficult breathing, listlessness, swelling of the legs, rotten gums, &c.

Another strong sign of the confirmed lues is often afforded from certain deep-seated nocturnal pains, particularly of the shins, arms, and head. As for any superficial wandering pains that have no fixed seat, and which affect the membranes of the muscles, and ligaments of the joints, they, for the most part, will be found to belong to the gout or rheumatism, and can never be considered as venereal, unless accompanied with some other evident signs; but with regard to the pains that are deeply-seated, and always fixed to the same place, and which affect the middle and more solid part of the ulna, tibia, and bones of the cranium, and rage chiefly and with greatest violence in the fore-part of the night, so that the patient can get no rest till morning approaches, these may serve to convince us that the disease has spread itself throughout the whole habit, whether they be accompanied with other symptoms of the lues or not. *Gummata* in the fleshy parts, *nodes* in the periosteum, *ganglia* upon the tendons, *tophi* upon the ligaments, *exostoses* upon the bones, and *fici* at the verge of the anus, are all of them signs of the confirmed lues: these are hard indolent swellings; but as they sometimes arise independently of any venereal infection, and perhaps may proceed from a scrophulous taint, unless they be accompanied or have been preceded by some of the more certain and evident symptoms of the lues, we must be cautious about pronouncing them venereal. When these swellings are not owing to the siphylitic virus, they are very seldom painful, or tend to inflame and suppurate, whereas those that are venereal usually do, and if they lie upon a bone generally bring on a caries.

These carious ulcers are most commonly met with upon the ulna, tibia, and bones of the cranium; and when accompanied with nocturnal pains, we can never hesitate about declaring their genuine nature. Frequent abortions, or the exclusion of scabby, ulcerated, half-rotten, and dead fœtuses, happening without any manifest cause to disturb the fœtus before its time, or to destroy it in the womb, may be reckoned as a sign that at least one of the parents is infected.

These then are the principal and most evident signs of the confirmed lues. There are others which are more equivocal, and which, unless we can fairly trace them back to some that are more certain, cannot be held as signs of the venereal disease: Such are, 1. Obstinate inflammations of the eyes, frequently returning, with great heat, itching, and ulceration of the eyelids. 2. A singing and hissing noise in the ears, with ulcers or caries in the bones of the meatus auditorius. 3. Obstinate headachs. 4. Obstinate cutaneous eruptions, of the itchy or leprous appearance, not yielding to the milder methods of treatment. 5. Swellings of the bones; and, 6. Wandering and obstinate pains. None of these symptoms, however, can be known to be venereal, except they happen to coincide with some one or other of the more certain signs.

It may, perhaps, be considered as a singularity in this disease, that the diagnosis is often more difficult in the advanced than in the early periods of the affection. That is, with those who have been certainly subjected to siphylis, it is often very difficult to say whether certain symptoms, remaining after the ordinary modes of cure have been employed, be siphylitic or not. Very frequently, as appears from the sequel, nocturnal pains, ulcerations, and the like, remaining after a long course of mercury has been employed, are in no degree of a venereal nature, but are in reality to be considered as consequences rather of the remedy than the disease; and are accordingly best removed by nourishing diet, gentle exercise, and tonics. But as long as any symptoms of any kind remain, it is often impossible to convince some patients that they are cured; and it is often impossible for a physician with certainty to affirm that the disease is altogether overcome.

Upon the whole, we are first to distinguish and consider the several symptoms apart; and then, by comparing them with each other, a clear judgment may be formed upon the general review.

Prognosis. Being thoroughly convinced that the case is venereal, we are to consider, first of all, whether it be of a longer or shorter date; for the more recent it is, it will, *cæteris paribus*, be less difficult to remove. But there are other circumstances which will assist us in forming a prognostic as to the event. As,

1. The age of the patient. This disorder is more dangerous to infants and old people, than to such as are in the flower and vigour of life, in whom some part of the virus may be expelled by exercise, or may be subdued in some degree by the strength of the constitution.

2. The sex. Though women are for the most part weaker than men, and therefore should seem less able to resist the force of any disease, yet experience shows that this is easier borne by them than by men; perhaps owing to the menstrual and other uterine discharges, by which a good portion of the virus may be carried off immediately from the parts where it was first applied; for it is observable, that whenever these discharges are obstructed, or cease by the ordinary course of nature, all the symptoms of this disease grow worse.

3. The habit of body. Persons who have acrid juices will be liable to suffer more from the venereal poison than such as have their blood in a milder state; hence, when people of a scorbutic or scrophulous habit contract venereal disorders, the symptoms are always remarkably violent, and difficult to cure. And for

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for the same reasons, the confirmed lues is much more to be dreaded in a person already inclined to an asthma, phthisis, dropsy, gout, or any other chronic distemper, than in one of a sound and healthy constitution. For as the original disease is increased by the accession of the venereal poison, so the lues is aggravated by being joined to an old disorder. The more numerous the symptoms, and the more they affect the bones, the more difficult the cure. Of all combinations the union of siphylis with scrophula is perhaps the most difficult to overcome: but if the acrimony should seize on the nobler internal parts, such as the brain, the lungs or the liver, then the disease becomes incurable, and the patient will either go off suddenly in an apoplectic fit, or sink under a consumption.

Cure. Viewing this disease as depending on a peculiar contagious matter introduced into the system, and multiplied there, it is possible to conceive that a cure may be obtained on one of three principles; either by the evacuation of the matter from the system, by the destruction of its activity, or by counteracting its influence in the system. It is not impossible that articles exist in nature capable of removing this complaint on each of these grounds: but we may venture at least to assert, that few such are yet discovered. Notwithstanding numbers of pretended infallible remedies for siphylis, mercury is perhaps the only article on which dependence is placed among European practitioners; and with regard to its mode of operation, all the three different opinions pointed out have been adopted and supported by different theorists.—But although many ingenious arguments have been employed in support of each, we are, upon the whole, inclined to think it more probable that mercury operates by destroying the activity of the venereal virus, than that it has effect either by evacuating it, or by exciting a state of action by which its influence is counteracted. Some practitioners have affirmed, that the disease may be totally extirpated without the use of mercury; but, excepting in slight cases, it appears from the most accurate observations, that this grand specific is indispensible; whether it be introduced through the pores of the skin, in the form of ointments, plasters, washes, &c.; or given by the mouth, disguised in the different shapes of pills, troches, powders, or solutions.

Formerly it was held as a rule, that a salivation ought to be raised, and a great discharge excited. But this is now found to be unnecessary: for as mercury probably acts by some specific power in subduing and correcting the venereal virus, all that is required is to throw in a sufficient quantity of the medicine for this purpose: and if it can be diverted from the salivary glands so much the better, since the inconveniences attending a spitting are such as we should always wish to avoid.

Mercury, when combined with any saline substance, has its activity prodigiously increased; hence the great variety of chemical preparations which have been contrived to unite it with different acids.

Corrosive sublimate, or the murias hydrargyri corrosivus, is one of the most active of all the mercurial preparations, insomuch as to become a poison even in very small doses. It therefore cannot safely be given in substance; but must be dissolved in order to render it capable of a more minute division. We may see, by looking into Wiseman, that this is an old medicine, though seldom given by regular practitioners. How it came to be introduced into so remote a part of the world as Siberia, is not easily found out; but Dr Clerc, author of the *Histoire Naturelle de l'Homme Malade*, assures us, that the sublimate solution has been in use there time out of mind.

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It appears to have been totally forgotten in other places, until of late years, when Baron Van Swieten brought it into vogue; so that at one period, if we may credit Dr Locker, they used no other mercurial preparation at Vienna. The number of patients cured by this remedy alone in the hospital of St Mark, which is under the care of this gentleman, from 1754 to 1761 inclusive, being 4880.

The method of preparing the solution is, to dissolve as much sublimate in any kind of ardent spirit (at Vienna they use only corn brandy) as will give half a grain to an ounce of solution. The dose to a grown person is one spoonful mixed with a pint of any light ptisan or barley water, and this is to be taken morning and evening: the patients should keep principally in a warm chamber, and lie in bed to sweat after taking the medicine; their diet should be light; and they ought to drink plentifully throughout the day, of whey, ptisan, or barley water. If the solution does not keep the belly open, a mild purge must be given from time to time; for Locker observes, that those whom it purges two or three times a-day, get well sooner than those whom it does not purge: he also says, that it very seldom affects the mouth, but that it promotes the urinary and cutaneous discharges. This course is not only to be continued till all the symptoms disappear, but for some weeks longer. The shortest time in which Locker used to let the patients out was six weeks; and they were continued on a course of decoction of the woods for some weeks after they left off the solution.

This method has been introduced both in Britain and Ireland, though by no means to the exclusion of others; but it appears, that the solution does not turn out so infallible a remedy, either in these kingdoms, or in France, as they say it has done in Germany. It was seldom if ever found to perform a radical cure, and the frequent use of it proved in many cases highly prejudicial. It has therefore been succeeded in practice, even at Vienna, by mercury exhibited in other forms; and, among these, by a remedy first recommended by Dr Plenck, and since improved by Dr Saunders; consisting of mercury united with mucilage of gum arabic, which is said to render its exhibition perfectly mild and safe. For particulars, we refer to Dr Saunders's treatise.

But a late French writer, supposed to be Dr Petit, in a small book, entitled, *A parallel of the different methods of treating the venereal disease*, insists, that there is neither certainty nor safety in any other method than the repeated frictions with mercurial ointment.

If, therefore, it is determined to have recourse to the mercurial frictions, the patient may with advantage be prepared by going into the warm bath some days successively; having been previously blooded if of a plethoric habit, and taking a dose or two of some proper cathartic.

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The patient being fitted with the necessary apparatus of flannels, is then to enter on the course.

If he be of a robust habit and in the prime of life, we may begin with two drams of the *unguentum hydrargyri fortius*, (Ph. Lond.) which is to be rubbed in about the ankles by an assistant whose hands are covered with bladders: then having intermitted a day, we may expend two drams more of the ointment, and rest for two days; after which, if no soreness of the mouth comes on, use only one dram; and at every subsequent friction ascend till the ointment shall reach the trunk of the body; after which the rubbings are to be begun at the wrists, and from thence gradually extended to the shoulders. In order to prevent the mercury from laying too much hold of the mouth, it must be diverted to the skin, by keeping the patient in a constant perspiration from the warmth of the room, and by drinking plentifully of barley-water, whey, or ptisan; but if, nevertheless, the mercury should tend to raise a spitting, then, from time to time, we are either to give some gentle cathartic, or order the patient into a vapour or warm bath; and thus we are to go on, rubbing in a dram of the ointment every second, third, or fourth night, according as it may be found to operate; and on the intermediate days either purging or bathing, unless we should choose to let the salivation come on; which, however, it is much better to avoid, as we shall thus be able to throw in a larger quantity of mercury.

It is impossible to ascertain the quantity of mercury that may be necessary to be rubbed in, as this will vary according to circumstances: but we are always to continue the frictions, for a fortnight at least, after all symptoms of the disease shall have totally disappeared; and when we have done with the mercury, warm bathing, and sudorific decoctions of the woods, are to be continued for some time longer.

This is a general sketch of the methods of treatment for the confirmed lues; but for a complete history of the disease, and for ample directions in every situation, we refer to Astruc, and his abridger Dr Chapman.—We have to add, however, that a method of curing this disease by mercurial fumigation has been lately recommended in France, but it seems not to meet with great encouragement. One of the most recent proposals for the cure of the venereal disease is that of Mr Clare, and consists in rubbing a small quantity of mercury under the form of the *submurias hydrargyri*, or *calomel* as it is commonly called, on the inside of the cheek; by which means it has been supposed that we will not only avoid the inconveniences of unction, but also the purgative effects that are often produced by this medicine when taken into the stomach. But after all, the introduction of mercury under the form of unction, as recommended by the latest and best writers in Britain on the venereal disease, Dr Swediaur, Mr John Hunter, and others, is still very generally preferred to any mode that has yet been proposed.

Where, after a long trial of mercury, distressing symptoms still remain, particularly obstinate ulcerations and severe pains, benefit has often been derived from the use of opium: but there is little reason to believe, as has been held by some, that of itself it affords an infallible cure of this disease; at least we are inclined to think, that all the facts hitherto brought in support of the cure of siphylis by opium are at the utmost very doubtful.

Scorbutus.

The same observation may perhaps be made with regard to another remedy which has of late been highly extolled in siphylis, viz. the nitric acid. This article seems to have been first introduced both against affections of the liver and venereal complaints by Dr Scott of Bombay. It has since been highly extolled by Dr Beddoes and other writers in Britain. And there are many well authenticated cases on record in which it has produced a cure. But it is very rarely preferable to mercury; and it is chiefly useful when, from some peculiarity of constitution, mercury cannot be exhibited.

In obstinate ulcerations, remaining probably after the venereal virus has been overcome, and resisting the use of mercury, a complete cure has in many instances been obtained from the use of the root of the mezereon, the daphne mezereum of Linnæus. This article has been chiefly employed under the form of decoction; and it now appears that it is the basis of an article at one time highly celebrated in venereal complaints, under the title of *Lisbon diet drink*. But, upon the whole, these sequelæ of this disease are perhaps more readily overcome by country air, gentle exercise, and nourishing diet, particularly a milk diet, than by the use of any medicine whatever. It must indeed be allowed, that for combating different sequelæ, various practices accommodated to the nature of these will on particular occasions be requisite. But into the consideration of these we cannot here propose to enter.

Genus LXXXVI. SCORBUTUS. 351

Scurvy.

Scorbutus, *Sauv.* gen. 391. *Lin.* 223. *Vog.* 318. *Sag.* 127. *Boerh.* 1148. *Hoffm.* III. 369. *Junck.* 91. *Lind* on the Scurvy. *Hulme* de Scorbuto. *Rouppe* de Morbis Navigantium.

Description. The first indication of the scorbutic diathesis is generally a change of colour in the face, from the natural and healthy look to a pale and bloated complexion, with a listlessness, and aversion from every sort of exercise; the gums soon after become itchy, swell, and are apt to bleed on the slightest touch; the breath grows offensive; and the gums, swelling daily more and more, turn livid, and at length become extremely fungous and putrid, as being continually in contact with the external air; which in every case favours the putrefaction of substances disposed to run into that state, and is indeed in some respects absolutely requisite for the production of actual putridity.

The symptoms of the scurvy, like those of every other disease, are somewhat different in different subjects, according to the various circumstances of constitution; and they do not always proceed in the same regular course in every patient. But what is very remarkable in this disease, notwithstanding the various and immense load of distress under which the patients labour, there is no sickness at the stomach, the appetite keeps up, and the senses remain entire almost to the very last: when lying at rest, scorbutic patients make no complaints, and feel little distress or pain; but the

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Scorbutic people, as the disease advances, are seldom free from pains; though they have not the same seat in all, and often in the same person shift their place. Some complain of universal pain in all their bones; but most violent in the limbs, and especially the joints: the most frequent seat of their pain, however, is some part of the breast. The pains of this disease seem to arise from the distraction of the sensible fibres by the extravasated blood being forced into the interstices of the periosteum and of the tendinous and ligamentous parts; whose texture being so firm, the fibres are liable to higher degrees of tension, and consequently of pain.

The states of the bowels are various: in some there is an obstinate costiveness; in others a tendency to a flux, with extremely fetid stools: the urine is also rank and fetid, generally high coloured; and, when it has stood for some hours, throws up an oily scum on the surface. The pulse is variable; but most commonly slower and more feeble than in the time of perfect health. A stiffness in the tendons, and weakness in the joints of the knees, appear early in the disease; but as it grows more inveterate, the patients generally lose the use of their limbs altogether; having a contraction of the flexor tendons in the ham, with a swelling and pain in the joint of the knee. Some have their legs monstrously swelled, and covered over with livid spots or ecchymoses; others have had tumours there; some, though without swelling, have the calves of the legs and the flesh of the thighs quite indurated. As persons far gone in the scurvy are apt to faint, and even expire, on being moved and brought out into the fresh air, the utmost care and circumspection are requisite when it is necessary to stir or remove them.

Scorbutic patients are at all times, but more especially as the disease advances, extremely subject to profuse bleedings from different parts of the body; as from the nose, gums, intestines, lungs, &c. and likewise from their ulcers, which generally bleed plentifully if the fungus be cut away. It is not easy to conceive a more dismal and diversified scene of misery than what is beheld in the third and last stage of this distemper; it being then that the anomalous and more extraordinary symptoms appear, such as the bursting out of old wounds, and the dissolution of old fractures that have been long united.

Causes. The term *scurvy* has been indiscriminately applied, even by physicians, to almost all the different kinds of cutaneous foulness; owing to some writers of the last century, who comprehended such a variety of symptoms under this denomination, that there are few chronic distempers which may not be so called, according to their scheme: but the disease here meant is the true putrid scurvy, so often fatal to seamen, that with many it has got the name of sea-scurvy, though it be a disease frequently occurring on shore, as was experienced by the British garrisons of Boston, Minorca, and many other places. Indeed no disease is perhaps more frequent or more destructive to people pent up in garrisons without sufficient supplies of sound animal food and fresh vegetables. It is sometimes known to be endemic in certain countries, where the nature of the soil, the general state of the atmosphere, and the common course of diet, all combine in producing that singular species of corruption in the mass of blood which constitutes the scorbutic diathesis; for the appearances, on dissecting scorbutic subjects, sufficiently show that the scurvy may, with great propriety, be termed a disease of the blood.

Dr Lind has, in a postscript to the third edition of his treatise on the scurvy, given the result of his observations drawn from the dissection of a considerable number of victims to this fatal malady; from which it appears that the true scorbutic state, in an advanced stage of the distemper, consists in numerous effusions of blood into the cellular interstices of most parts of the body, superficial as well as internal; particularly the gums and the legs; the texture of the former being almost entirely cellular, and the generally dependent state of the latter, rendering these parts of all others in the whole body, the most apt to receive and

and retain the stagnant blood, when its crasis comes to be destroyed; and when it loses that glutinous quality which, during health, hinders it from escaping through the pores in the coats of the blood-vessels or through exhalant extremities.

A dropsical indisposition, especially in the legs and breasts was frequently, but not always, observed in the subjects that were opened, and the pericardium was sometimes found distended with water: the water thus collected was often so sharp as to shrivel the hands of the dissector; and in some instances, where the skin happened to be broken, it irritated and festered the wound.

The fleshy fibres were found so extremely lax and tender, and the bellies of the muscles in the legs and thighs so stuffed with the effused stagnating blood, that it was always difficult, and sometimes impossible, to raise or separate one muscle from another. He says that the quantity of this effused blood was amazing; in some bodies it seemed that almost a fourth part of the whole mass had escaped from the vessels; and it often lay in large concretions on the periosteum, and in some few instances under this membrane immediately on the bone. Notwithstanding this dissolved and depraved state of the external fleshy parts, the brain always appeared perfectly sound, and the viscera of the abdomen, as well as those of the thorax, were in general found quite uncorrupted. There were spots indeed, from extravasated blood, observed on the mesentery, intestines, stomach, and omentum; but these spots were firm, and free from any mortified taint; and, more than once, an effusion of blood, as large as a hand's-breadth, has been seen on the surface of the stomach; and what was remarkable, that very subject was not known while living to have made any complaint of sickness, pain, or other disorder, in either stomach or bowels.

These circumstances and appearances, with many others that are not here enumerated, all prove to a demonstration a putrescent, or at least a highly depraved state of the blood: and yet Dr Lind takes no small pains to combat the idea of the scurvy's proceeding from animal putrefaction; a notion which, according to him, "may, and hath misled physicians to propose and administer remedies for it altogether ineffectual."

He also, in the preface to his third edition, talks of the mischief done by an attachment to delusive theories. He says, "it is not probable that a remedy for the scurvy will ever be discovered from a preconceived hypothesis, or by speculative men in the closet, who have never seen the disease, or who have seen at most only a few cases of it;" and adds, "that though a few partial facts and observations may, for a little, flatter with hopes of greater success, yet more enlarged experience must ever evince the fallacy of all positive assertions in the healing art."

Sir John Pringle, however, is of a very different opinion. He "is persuaded, after long reflection, and the opportunities he has had of conversing with those who to much sagacity had joined no small experience in nautical practice, that upon an examination of the several articles which have either been of old approved, or have of late been introduced into the navy, it will appear, that though these means may vary in form and in mode of operating, yet they all some way contribute towards preventing putrefaction; whether of the air in the closer parts of a ship, of the meats, of the water, of the clothes and bedding, or of the body itself."

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What Dr Lind has above advanced is the more remarkable, as, in the two former editions of his book, he embraced the hypothesis of animal putrefaction being the cause of the scurvy; and if these effusions of blood, from a destruction of its crasis and the dissolved state of the muscular fibres, together with the rotten condition of the mouth and gums, do not betray putrescency, it is hard to say what does, or what other name we shall bestow on this peculiar species of depravation which constitutes the scurvy.

The blood, no doubt, derives its healthy properties, and maintains them, from the due supplies of wholesome food; while the insoluble, superfluous, effete, and acrid parts, are carried off by the several discharges of stool, urine, and perspiration,

Our senses of taste and smell are sufficient to inform us when our food is in a state of soundness and sweetness, and consequently wholesome; but it is from chemistry that we must learn the principles on which these qualities chiefly depend.

Experiments of various kinds have proved, that the soundness of animal and vegetable substances depends very much, if not entirely, on the presence of their aërial principle. Rottenness is never observed to take place without an emission of fixed air from the putrefying substance: and even when putrefaction has made a considerable progress, if aërial acid can be tranferred, in sufficient quantity, from some other substance in a state of effervescence or fermentation, into the putrid body, the offensive smell of this will be destroyed. If it be a bit of rotten flesh with which the experiment is made, the firmness of its fibres will be found in some measure restored.

The experiments of Dr Hales, as well as many others made since his time, show that an aërial principle is greatly connected with, and particularly abundant in, the gelatinous parts of animal bodies, and in the mucilage or farina of vegetables. But these are the parts of our food which are most particularly nutritive; and Dr Cullen, whose opinion on this as on every other medical subject must be allowed of the greatest weight, affirms, in his Lectures on the Materia Medica, that the substances on which we feed are nutritious only in proportion to the quantities of oil and sugar which they respectively contain. This oil and sugar are blended together in the gelatinous part of our animal food, and in the mucilaginous and farinaceous part of esculent vegetables; and, while thus intimately combined, are not perceivable by our taste, though very capable of being developed and rendered distinct by the power of the digestive organs; for in consequence of the changes produced during digestion, the oily and the saccharine matter become manifest to our senses, as we may see and taste in the milk of animals, which is chiefly chyle a little advanced in its progress toward sanguification; the oil is observed to separate spontaneously, and from which a quantity of actual sugar may be obtained by a very simple process.

Thus much being premised, we can now readily comprehend

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comprehend how the blood may come to lose those qualities of smoothness, mildness, and tenacity which are natural to it. For if, in the first place, the fluids, and organs subservient to digestion, should be so far distempered or debilitated that the nutritious parts of the food cannot be properly developed, the blood must be defrauded of its due supplies; which will also be the case if the aliment should not originally contain enough of oily and saccharine matter, or should be so circumstanced, from being dried or salted, as to hinder the ready extrication of the nutritious parts; or, lastly, if the natural discharges should be interrupted or suspended, so that the superfluous, acrid, and effete fluids are retained in the general mass; in all these instances the blood must of necessity run into proportionate degrees of depravation.

And hence we may understand how it may possibly happen, that when persons are greatly weakened by some preceding disorder, and at the same time debarred the use of proper bodily exercise, the scorbutic diathesis should take place, even though they enjoy the advantages of pure air and wholesome diet. But these are solitary cases, and very rarely seen; for whenever the scurvy seizes numbers, and can be considered as an epidemic disease, it will be found to depend on a combination of the major part, or perhaps all, of the following circumstances:

1. A moist atmosphere, and more especially if cold be joined to this moisture. 2. Too long cessation from bodily exercise, whether it be from constraint, or a lazy slothful disposition. 3. Dejection of mind. 4. Neglect of cleanliness, and want of sufficient clothing. 5. Want of wholesome drink, either of pure water or fermented liquors. And, 6. Above all, the being obliged to live continually on salted meats, perhaps not well cured, without a due proportion of the vegetables sufficient to correct the pernicious tendency of the salt, by supplying the bland oil and saccharine matter requisite for the purposes of nutrition.

These general principles respecting the causes and nature of scurvy, seem to afford a better explanation of the phenomena of the disease than any conjectures respecting it that have hitherto been proposed. It must, however, be allowed, that Dr Lind is by no means the only writer who is disposed to consider this disease as not referable to the condition of the circulating fluids. In a late ingenious treatise on this subject by Sir F. Milman, he strenuously contends, that the primary morbid affection in this complaint is a debilitated state of the solids arising principally from want of aliment. But his arguments on this subject, as well as those of Dr Lind, are very ably answered by a still later writer on this subject, Dr Trotter, who has drawn his observations respecting it from very extensive experience, and who considers it as clearly established, by incontrovertible facts, that the proximate cause of scurvy depends on some peculiar state of the blood.—That this disease does not depend on a debilitated state of the solids, is demonstratively proved from numerous cases where every possible degree of debility occurs in the solids without the slightest appearance of scurvy. Dr Trotter, in the second edition of his Observations on the Scurvy, from the result of farther observation and later discoveries in chemistry, has attempted, with much ingenuity, to prove that the morbid condition of the blood, which takes place in scurvy, arises from the abstraction of vital air, or, as it is now generally called, *oxygene;* and this opinion, though still, perhaps, in some particulars requiring farther confirmation, is, it must be allowed, supported by many plausible arguments.

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Prevention and Cure. The scurvy may be prevented, by obviating and correcting those circumstances in respect of the non-naturals which were mentioned as contributing to the disease, and laid down as causes. It is, therefore, a duty highly incumbent on officers commanding at sea, or in garrisons, to use every possible precaution; and, in the first place, to correct the coldness and moisture of the atmosphere by sufficient fires: in the next, to see that their men be lodged in dry, clean, and well ventilated births or apartments: thirdly, to promote cheerfulness, and enjoin frequent exercise, which alone is of infinite use in preventing the scurvy: fourthly, to take care that the clothing be proper, and cleanliness of person strictly observed: fifthly, to supply them with wholesome drink, either pure water or sound fermented liquors; and if spirits be allowed, to have them properly diluted with water and sweetened with melasses or coarse sugar: and lastly, to order the salted meats to be sparingly used, or sometimes entirely abstained from; and in their place, let the people live on different compositions of the dried vegetables; fresh meat and recent vegetables being introduced as often as they can possibly be procured.

A close attention to these matters will, in general, prevent the scurvy from making its appearance at all, and will always hinder it from spreading its influence far. But when these precautions have been neglected, or the circumstances such that they cannot be put in practice, and the disease has actually taken place, our whole endeavour must be to restore the blood to its original state of soundness: and happily, such is the nature of this disease, that if a sufficiency of new matter, of the truly mild nutritious sort, and particularly such as abounds with vital air, such as recent vegetables, or different acid fruits, can be thrown into the circulation while the fleshy fibres retain any tolerable degree of firmness, the patient will recover; and that in a surprisingly short space of time, provided a pure air, comfortable lodgings, sufficient clothing, cleanliness, and exercise, lend their necessary aid.

This being the case, the plan of treatment is to be conducted almost entirely in the dietetic way; as the change in the mass of blood, which it is necessary to produce, must be brought about by things that can be received into the stomach by pints or pounds, and not by those which are administered in drops or grains, drams or ounces. For here, as there is no disorder of the nervous system, we have no need of those active drugs which are indispensably necessary in febrile or nervous diseases; the scorbutic diathesis being quite opposite to that which tends to produce a fever or any species of spasmodic disorders; nay Dr Lind says, he has repeatedly found, that even the infection of an hospital fever is long resisted by a scorbutic habit.

It will now naturally occur to the reader, what those alimentary substances must be which bid the fairest

fairest to restore the blood to its healthy state; and he needs scarcely to be told, that they are of those kinds which the stomach can bear with pleasure though taken in large quantities, which abound with jelly or mucilage, and which allow those nutritious parts to be easily developed; for though the viscera in scorbutic patients may be all perfectly sound, yet we cannot expect that either the digestive fluids or organs should possess the same degrees of power, which enable them, during health, to convert the crude dry farinacea, and the hard salted flesh of animals, into nourishment. We must therefore search for the *antiscorbutic virtue* in the tender sweet flesh of herbivorous animals; in new milk; and in the mucilaginous acid juices of recent vegetables, whether they be fruits, leaves, or roots.

The sour juices of lemons, oranges, and limes, have been generally held as antiscorbutics in an eminent degree, and their power ascribed to their acid; from an idea that acids of all kinds are the only correctors of putrefaction. But the general current of practical observations shows, and our experiments confirm it, that the virtue of these juices depends on their *aerial principle*; accordingly, while perfectly recent and in the mucilaginous state, and especially if mixed with wine and sugar, the juices of any one of these fruits will be found a most grateful and powerful antiscorbutic.

Dr Lind observing, "that the lemon juice, when given by itself undiluted, was apt, especially if overdosed, to have too violent an operation, by occasioning pain and sickness at the stomach, and sometimes a vomiting; found it necessary to add to it wine and sugar. A pint of Madeira wine, and two ounces of sugar, were put to four ounces and a half of juice, and this quantity was found sufficient for weak patients to use in 24 hours: such as were very weak sipped a little of this frequently according as their strength would permit; others who were stronger took about two ounces of it every two hours; and when the patients grew still stronger, they were allowed eight ounces of lemon juice in 24 hours."

While this very pleasant mixture, which is both a cordial and an antiseptic, may be had, it would be needless to think of prescribing any other; but when the fresh juice cannot be procured, we must have recourse to such other things as may be obtained. But the various modes of combining and administering these, so as to render them perfectly agreeable to the stomach, must always be regulated by circumstances, and therefore it will be in vain to lay down particular directions; since all that we have to do is, to fix on such fruits and other fresh vegetables as can be most conveniently had and taken, and contrive to give them in those forms, either alone or boiled up with flesh meat into soups, which will allow the patients to consume the greatest quantities.

The first promising alteration from such a course is usually a gentle diarrhœa; and if, in a few days, the skin becomes soft and moist, it is an infallible sign of recovery; especially if the patient gain strength, and can bear being stirred or carried into the open air without fainting.

But if the belly should not be loosened by the use of the fresh vegetables, nor the skin become soft and moist, then they must be assisted by stewed prunes, or a decoction of tamarinds with supertartrite of potash, in order to abate the costiveness; and by drinking a little decoction of the woods, and warm bathing, in order to relax the pores of the skin; for nothing contributes more to the recovery of scorbutic patients than moderate sweating.

With regard to particular symptoms, antiseptic mouth waters, composed of a decoction of cinchona and infusion of roses, with a solution of myrrh, must be used occasionally, in order to cleanse the mouth, and give firmness to the spongy gums. Swelled and indurated limbs, and stiffened joints, must be bathed with warm vinegar, and relaxed by the steam of warm water, repeatedly conveyed to them, and confined to the parts by means of close blankets: ulcers on the legs must never be treated with unctuous applications nor sharp escharotics; but the dressing should consist of lint or soft rags, dipt in a strong decoction of cinchona.

This disease at no time requires, or indeed bears large evacuations, either by bleeding or purging; and as has been already mentioned, the belly must only be kept open by the fresh vegetables or the mildest laxatives. Be we are always to be careful that scorbutic persons, after a long abstinence from greens and fruits, be not permitted to eat voraciously at first, lest they fall into a fatal dysentery.

All, however, that has now been laid down as necessary towards the cure, supposes the patients to be in situations where they can be plentifully furnished with all the requisites; but unhappily these things are not to be procured at sea, and often deficient in garrisons: in order therefore, that a remedy for the scurvy might never be wanting, Dr Macbride in the year 1762, first conceived the notion, that the *infusion of malt*, commonly called *wort*, might be substituted for the common antiscorbutics; and it was accordingly tried.

More than three years elapsed before any account arrived of the experiments having been made: at length, ten histories of cases were received, wherein the wort had been tried, with very remarkable success; and this being judged a matter of great importance to the seafaring part of mankind, these were immediately communicated to the public in a pamphlet, under the title of *An historical account of a new method of treating the scurvy at sea.*

This was in 1767; but after that time a considerable number of letters and medical journals, sufficient to make up a small volume, were transmitted to Dr Macbride, particularly by the surgeons of his majesty's ships who had been employed of late years for making discoveries in the southern hemisphere. Certain it is, that in many instances it has succeeded beyond expectation. In others it has fallen short: but whether this was owing to the untoward situation of the patients, or inattention on the part of the persons who were charged with the administration of the wort, not preparing it properly, or not giving it in sufficient quantity, or to its own want of power, must be collected from the cases and journals themselves.

During Captain Cook's third voyage, the most remarkable, in respect of the healthiness of the crew, that ever was performed, the wort is acknowledged to have been of singular use.

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In a letter which this very celebrated and successful circumnavigator wrote to Sir John Pringle, he gives an account of the methods pursued for preserving the health of his people; and which were productive of such happy effects, that he performed "a voyage of three years and 18 days, through all the climates from 52° north to 71° south, with the loss of one man only by disease, and who died of a complicated and lingering illness, without any mixture of scurvy. Two others were unfortunately drowned, and one killed by a fall; so that out of the whole number 118 with which he set out from England, he lost only four."

He says, that much was owing to the extraordinary attention of the admiralty, in causing such articles to be put on board as either by experience or conjecture were judged to tend most to preserve the health of seamen: and with respect to the wort, he expresses himself as follows:

"We had on board a large quantity of *malt*, of which was made *sweet wort*, and given (not only to those men who had manifest symptoms of the scurvy, but to such also as were, from circumstances, judged to be most liable to that disorder) from one or two to three pints in the day to each man, or in such proportion as the surgeon thought necessary, which sometimes amounted to three quarts in the 24 hours: this is without doubt one of the best sea antiscorbutic medicines yet found out; and if given in time, will, with proper attention to other things, I am persuaded, prevent the scurvy from making any great progress for a considerable time: but I am not altogether of opinion that it will cure it, in an advanced state, at sea."

On this last point, however, the captain and his surgeon differ; for this gentleman positively asserts, and his journal (in Dr Macbride's possession) confirms it, that the infusion of malt did effect a cure in a confirmed case, and at sea.

The malt being thoroughly dried, and packed up in small casks, is carried to sea, where it will keep sound, in every variety of climate, for at least two years: when wanted for use, it is to be ground in a hand mill, and the infusion prepared from day to day, by pouring three measures of boiling water on one of the ground malt; the mixture being well mashed, is left to infuse for 10 or 12 hours, and the clear infusion then strained off. The patients are to drink it in such quantities as may be deemed necessary, from one to three quarts in the course of the 24 hours: a panada is also to be made of it, by adding biscuit, and currants or raisins; and this palatable mess is used by way of solid food. This course of diet, like that of the recent vegetables, generally keeps the bowels sufficiently open; but in cases where costiveness nevertheless prevails, gentle laxatives must be interposed from time to time, together with diaphoretics, and the topical assistants, fomentations and gargles, as in the common way of management.

Captain Cook was also provided with a large stock of *sour krout*; (cabbage leaves cut small, fermented and stopped in the second stage of fermentation, and afterwards preserved by a due quantity of salt). A pound of this was served to each man twice a-week, while they were at sea. Sour krout, since the trial made of it on board Captain Cook's ships, has been extensively used by direction of the British government in many other situations, where scorbutus has prevailed; and it has been found to be highly serviceable both in preventing and in curing the disease. It was particularly found, during the late American war, to be highly beneficial to the British troops besieged in Boston, who were at that time entirely fed on salt provisions sent from England, and among whom true scorbutus was very fatal till the sour krout arrived. The scurvy at one period broke out among them with very alarming appearances; but by the seasonable arrival of a quantity of sour krout, it was effectually overcome. Care, however, must be bestowed, that this article be properly prepared and properly kept. When due attention is paid to these particulars, it may be preserved in good condition for many months; and is considered both by sailors and soldiers as a very acceptable addition to their salt provisions. But when served out to them in a putrid state, it is not only highly disagreeable to the taste, but probably also pernicious in its effects.

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Among other means of preventing scurvy, Captain Cook had also a liberal supply of *portable soup*; of which the men had generally an ounce, three days in the week, boiled up with their pease; and sometimes it was served to them oftener; and when they could get fresh greens, it was boiled up with them, and made such an agreeable mess, that it was the means of making the people eat a greater quantity of greens than they would otherwise have done. And what was still of further advantage, they were furnished with sugar in lieu of butter or oil, which is seldom of the sweetest sort; so that the crew were undoubtedly great gainers by the exchange.

In addition to all these advantages of being so well provided with every necessary, either in the way of diet or medicine, Captain Cook was remarkably attentive to all the circumstances respecting cleanliness, exercise, sufficient clothing, provision of pure water, and purification of the air in the closer parts of the ship.

From the effect of these different means, as employed by Captain Cook, there can be little doubt that they will with due attention be sufficient for the prevention and cure of the disease, at least in most situations: but besides these, there are also some other articles which may be employed with great advantage.

Newly brewed spruce beer made from a decoction of the tops of the spruce fir and melasses, is an excellent antiscorbutic; it acts in the same way that the wort does, and will be found of equal efficacy, and therefore may be substituted. Where the tops of the spruce fir are not to be had, this beer may be prepared from the essence of spruce, as it has been called, an article which keeps easily for a great length of time. But in situations where neither the one nor the other can be had, a most salutary mess may be prepared from oatmeal, by infusing it in water, in a wooden vessel, till it ferments, and begins to turn sourish; which generally happens, in moderately warm weather, in the space of two days.—The liquor is then strained off from the grounds, and

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Nothing is more commonly talked of than a *land scurvy*, as a distinct species of disease from that which has been now described; but no writer has yet given a description so clear as to enable us to distinguish it from the various kinds of cutaneous foulness and eruption, which indeed are vulgarly termed *scorbutic*, but which are akin to the itch or leprosy, and for the most part require mercurials. These, however, are very different diseases from the true scorbutus, which, it is well known, may prevail in certain situations on land as well as at sea, and is in no degree to be attributed to sea air.

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Genus LXXXVII. ELEPHANTIASIS.

Elephantiasis, *Sauv.* gen. 302. *Vog.* 321. *Sag.* gen. 128.

Elephantia Arabum, *Vog.* 322.

The best account of this disease is that by Dr Heberden, published in the first volume of the Medical Transactions. According to him, frequently the first symptom is a sudden eruption of tubercles, or bumps of different sizes, of a red colour, more or less intense (attended with great heat and itching) on the body, legs, arms, and face; sometimes in the face and neck alone, at other times occupying the limbs only; the patient is feverish; the fever ceasing, the tubercles remain indolent, and in some degree scirrhous, of a livid or copper colour, but sometimes of the natural colour of the skin, or at least very little altered; and after some months they not unfrequently ulcerate, discharging a fetid ichorous humour in small quantity, but never laudable pus.

The features of the face swell and enlarge greatly; the part above the eyebrows seems inflated; the hair of the eyebrows falls off, as does the hair of the beard; but Dr Heberden has never seen any one whose hair has not remained on his head. The *alæ nasi* are swelled and scabrous; the nostrils patulous, and sometimes affected with ulcers, which, corroding the cartilage and *septum nasi*, occasion the nose to fall. The lips are tumid; the voice is hoarse; which symptom has been observed when no ulcers have appeared in the throat, although sometimes both the throat and gums are ulcerated. The ears, particularly the lobes, are thickened, and occupied by tubercles. The nails grow scabrous and rugose, appearing something like the rough bark of a tree; and the distemper advancing, corrodes the parts gradually with a dry sordid scab or gangrenous ulcer; so that the fingers and toes rot and separate joint after joint. In some patients the legs seem rather posts than legs, being no longer of the natural shape, but swelled to an enormous size, and indurated, not yielding to the pressure of the fingers; and the superficies is covered with very thin scales, of a dull whitish colour, seemingly much finer, but not so white as those observed in the *lepra Græcorum*. The whole limb is overspread with tubercles, interspersed with deep fissures; sometimes the limb is covered with a thick moist scabby crust, and not unfrequently the tubercles ulcerate. In others the legs are emaciated, and sometimes ulcerated; at other times affected with tubercles without ulceration. The muscular flesh between the thumb and forefinger is generally extenuated. Elephantiasis.

The whole skin, particularly that of the face, has a remarkably shining appearance, as if it was varnished or finely polished. The sensation in the parts affected is very obtuse, or totally abolished; so that pinching, or puncturing the part, gives little or no uneasiness; and in some patients, the motion of the fingers and toes is quite destroyed. The breath is very offensive; the pulse in general weak and slow.

The disease often attacks the patient in a different manner from that above described, beginning almost insensibly; a few indolent tubercles appearing on various parts of the body or limbs, generally on the legs or arms, sometimes on the face, neck, or breast, and sometimes in the lobes of the ears, increasing by very slow degrees, without any disorder, previous or concomitant, in respect of pain or uneasiness.

To distinguish the distemper from its manner of attacking the patient, Dr Heberden styles the first by *fluxion* and the other by *congestion*. That by fluxion is often the attendant of a crapula, or surfeit from gross foods; whereby, perhaps, the latent seeds of the disorder yet dormant in the mass of blood are excited; and probably from frequent observations of this kind (the last meal being always blamed), it is, that, according to the received opinion, either fish, (the tunny, mackarel, and shell-fish, in particular), melons, cucumbers, young garden-beans, or mulberries, eaten at the same meal with butter, cheese, or any preparation of milk, are supposed to produce the distemper, and are accordingly religiously avoided.

Violent commotions of the mind, as anger, fear, and grief, have more than once been observed to have given rise to the disorder: and more frequently, in the female sex, a sudden suppression of an accustomed evacuation, by bathing the legs and feet in cold water at an improper season.

The disorder by fluxion is what is the oftenest endeavoured to be remedied by timely application; that by congestion, not being so conspicuous, is generally either neglected or attempted to be concealed, until perhaps it be too late to be cured, at least unless the patients would submit to a longer course of medicine and stricter regimen of diet than they are commonly inclined to do.

Several incipient disorders by fluxion have been known to yield to an antiphlogistic method, as bleeding, refrigerant salts in the saline draughts, and a solution of crystals of tartar in water, for common drink, (by this means endeavouring to precipitate part of the peccant matter, perhaps too gross to pass the pores by the kidneys); and when once the fever is overcome, cinchona combined with sassafras, is the remedy principally to be relied on. The only topical medicine prescribed by Dr Heberden, was an attenuating embrocation of brandy and alkaline spirit. By the same method some confirmed cases have been palliated. But, excepting in one patient, Dr Heberden never saw or heard of a confirmed elephantiasis radically cured. He adds, however, that he never met with another patient possessed of prudence and perseverance enough to prosecute the cure as he ought.

 Genus

Impetigines.

353 Genus LXXXVIII. LEPRA.

The *Leprosy*.

Lepra, *Sauv.* gen. 303. *Lin.* 262. *Sag.* 129.
Lepra *Græcorum*, *Vog.* 320.

This distemper is but little known to physicians in the western parts of Europe. Wallis tells us, that it first begins with red pimples, or pustules, breaking out in various parts of the body. Sometimes they appear single; sometimes a great number arise together, especially on the arms and legs; as the disease increases, fresh pimples appear, which, joining the former, make a sort of clusters; all which enlarge their borders, and spread in an orbicular form. The superficies of these pustules are rough, whitish, and scaly; when they are scratched the scales fall off, upon which a thin ichor oozes out, which soon dries and hardens into a scaly crust. These clusters of pustules are at first small and few; perhaps only three or four in an arm or leg, and of the size of a silver penny. But if the disease be suffered to go on, they become more numerous, and the clusters increase to the size of a crown-piece, but not exactly round. Afterwards the affection increases to such a degree, that the whole body is covered with a leprous scurf. The cure of this distemper is very much the same with that of the Elephantiasis. Here, however, recourse is frequently had to antimonial and mercurial medicines, continued for a considerable length of time. In conjunction with these, warm bathing, particularly the vapour bath, has often been employed with advantage.

Although what can strictly be called lepra is now, at least, a very rare disease in this country, yet to this general head may be referred a variety of cutaneous affections which are here very common, and which in many instances prove very obstinate. These appear under a variety of different forms: sometimes under that of red pustules: sometimes of white scurfs; sometimes of ulcerations; and not unfrequently a transition takes place from one form to another, so that they cannot be divided into different genera from the external appearance. These affections will often yield to the remedies already mentioned; but where antimonials and mercurials either fail, or from different circumstances are considered as unadviseable, a cure may sometimes be effected by others. In particular cases, purging mineral waters, the decoction of cinchona, the infusion of the œnanthe crocata, and various others, have been employed with success. Different external applications also have sometimes been employed with advantage. An article used in this way, known under the name of Gowland's lotion, with the composition of which we are unacquainted, has been much celebrated, and has been said to be employed with great success, particularly against eruptions on the face and nose.

354 Genus LXXXIX. FRAMBOESIA.

The *Yaws*.

Frambœsia, *Sauv.* gen. 125. *Sag.* 125.

Description. The description which is given of this distemper by the anonymous author of a paper in the 6th volume of the Edinburgh Medical Essays, (art. 76.) differs, in some circumstances, from one that Sauvages received from M. Virgile, an eminent surgeon of Montpelier, who practised twelve years in the island of St Domingo; and therefore he distinguishes the *frambœsia* into two species, *Guineensis* and *Americana*.

Frambœsia.

The *frambœsia Guineensis* is said by the first-mentioned writer to be so common on the coast of Guinea and other parts of Africa, that it seldom fails to attack each individual of both sexes, one time or other, in the course of their lives: but most commonly during childhood or youth. "It makes its appearance in little spots on the cuticle, level with the skin, at first no larger than a pin's head, which increase daily, and become protuberant like pimples: soon after the cuticle frets off, and then, instead of finding pus or ichor, in this small tumor, only white sloughs or sordes appear, under which is a small red fungus, growing out of the cutis, increasing gradually to very different magnitudes, some less than the smallest wood strawberry, some as big as a raspberry, and others exceeding in size even the largest mulberries; which berries they very much resemble, being knobbed as these are." These protuberances, which give the name to the disease, appear on all parts of the body: but the greatest numbers, and the largest sized, are generally found in the groins, and about the pudenda or anus, in the armpits, and on the face: when the yaws are very large, they are few in number; and when remarkably numerous, they are less in size. The patients, in all other respects, enjoy good health, do not lose their appetite, and seem to have little other uneasiness than what the sores occasion.

M. Virgile describes the species of yaws that is common among the negroes of St Domingo, and which Sauvages has termed *frambœsia Americana*, as beginning from an ulcer that breaks out indiscriminately in different parts of the body, though most commonly on the legs; at first superficial, and not different from a common ulcer in any other circumstance saving its not healing by the usual applications; sooner or later, numerous fungous excrescences break out on the surface of the body, as before described, like little berries, moist, with a reddish mucus. Besides these, the soles of the feet and palms of the hands become raw, the skin fretting off, so as to leave the muscles bare; these excoriations are sometimes moist with ichor and sometimes dry, but always painful, and consequently very distressing. They are mentioned also by the author of the article in the Medical Essays; and both he and M. Virgile observe, that there is always one excrescence, or yaw, of an uncommon size, which is longer in falling off than the others, and which is considered as the *master-yaw*, and so termed. An ingenious inaugural dissertation on the subject of the yaws was lately published at Edinburgh by Dr Jonathan Anderson Ludford, now physician in Jamaica. The author of that dissertation considers Dr Cullen as improperly referring frambœsia to the class of cachexiæ. He thinks that this disease ought rather to be referred to the exanthemata; for, like the smallpox, he tells us, it has its accession, height, and decline. It begins with some degree of fever either more or less violent; it may be propagated by inoculation; and it attacks the apeti- ines. the same individual only once in the course of a lifetime, those who recover from the disease being never afterwards affected with it. These particulars respecting framboesia are rested not merely on the authority of Dr Ludford, but are supported also by the testimony of Dr William Wright, a physician of distinguished eminence, who, while he resided in Jamaica, had, in the course of extensive practice, many opportunities of observing this disease, and to whom Dr Ludford acknowledges great obligations for having communicated to him many important facts respecting it.

Dr Ludford considers the yaws as being in every instance the consequence of contagion, and as depending on a matter *sui generis*. He supposes no peculiar predisposition from diet, colour, or other circumstances, as being in any degree necessary. He views the disease as chiefly arising from contact with the matter, in consequence of sleeping in the same bed, washing in the same vessel with the infected, or the like. In short, the yaws may be communicated by any kind of contact; nay, it is even believed that flies often convey the infection, when, after having gorged themselves with the virulent matter by sucking the ulcers of those who are diseased, they make punctures in the skin of such as are sound, and thus inoculate them; in consequence of which the disorder will soon appear.

Prognosis. The yaws are not dangerous, if the cure be skilfully managed at a proper time; but if the patient has been prematurely salivated, or has taken any quantity of mercury, and if his skin has been suddenly cleared, the cure will be very difficult, if not impracticable.

Cure. In attempting the cure of this disease, the four following indications are chiefly to be held in view:

1. To support the strength of the patient.
2. To promote excretion by the skin.
3. To correct the vitiated fluids.
4. To remove and counteract the injuries done either to the constitution in general, or to particular parts, by the disease.

With the first of these intentions, a liberal diet, consisting of a considerable quantity of animal food, with a considerable proportion of wine, and gentle exercise, are to be employed: but the cure is principally to be effected by mercurial salivation, after the virulent matter has been completely thrown out to the surface of the body by sudorifics. The following are the particular directions given on this head by the author of the article in the Medical Essays. The yaws being an infectious disease, as soon as they begin to appear on a negro, he must be removed to a house by himself; or, if it is not certain whether the eruption be the yaws or not, shut him up seven days, and look on him again, as the Jews were commanded to do with their lepers, and in that time you may in most cases be certain.

As soon as you are convinced that it is the yaws, give a bolus of flowers of sulphur, with camphor and theriaca. Repeat this bolus every night for a fortnight or three weeks, or till the yaws come to the height; that is, when they neither increase in size or number: then throw your patient into a gentle salivation with calomel given in small doses, without farther preparation; five grains repeated once, twice, or thrice a-day, is sufficient, as the patient can bear it. If he spits a quart in 24 hours, it is enough. Generally, when the salivation is at this height, all the yaws are covered with dry scaly crusts or scabs; which, if numerous, look terribly. These fall off daily in small white scales; and in ten or twelve days leave the skin smooth and clean. Then the calomel may be omitted, and the salivation permitted to go off spontaneously. A dram of corrosive sublimate dissolved in an ounce of rum or brandy, and the solution daubed on the yaws, will, it is said, in general clear the skin in two days time. Framboesia.

After the salivation, sweat the patient twice or thrice in a frame or chair with spirits of wine; and give an alterative electuary of æthiops and gum guaiac. He may likewise use the decoction of guaiacum and sassafras fermented with melasses, for his constant drink while the electuary is taking, and a week or a fortnight after the electuary is finished.

The master yaw must be consumed an eighth or a tenth part of an inch below the skin, with *Mercur. corros. rub. et alum. ust. part. æqual.* and digested with *Ung. basil. flav.* ℥j. and *mercur. corros. rub.* ʒj. and cicatrized with lint pressed out of spirits of wine, and with the sulphate of copper.

After the yaws are cured, some patients are afflicted with carbuncles in their feet; which sometimes render them incapable of walking, unless with pain. The method of cure is, by bathing and paring to destroy the cuticle, and then proceed as in the master-yaw. The gentle escharotics are to be preferred; and all imaginable care is to be taken to avoid the tendons and periosteum.

To children under six or seven years old, at the proper time of salivating, when the yaws are come to their full growth, give a grain or two of calomel in white sugar, once a-day, once in two days, or once in three days, so as only to keep their mouths a little sore till the yaws dry, and, falling off in white scales, leave the skin clean. This succeeds always, but requires a longer time than in adults.

In St Domingo they are salivated by unction; but it does not appear that success always followed this practice. It is also usual in that island to give the solution of corrosive sublimate along with a decoction of sarsaparilla. Twelve ounces of this root, and 12 pounds of the coarsest sugar, macerated for 15 days in 12 quarts of water, is mentioned as a specific, and said to be the prescription of an English physician; the dose is four ounces every sixth hour.

Genus XC. TRICHOMA. 355

The *Plica Polonica*, or *Plaited Hair*.

Trichoma, *Sauv.* gen. 311. *Sag.* 137.
Plica, *Lin.* 313.
Plica sive Rhopalosis, *Vog.* 323.

This disorder is only met with in Poland and Lithuania, and consists of several blood-vessels running from the head into the ends of the hairs; which cleave together, and hang from the head in broad flat pieces, generally about an ell in length, but sometimes they are five

Impetigines. five or six yards long; one patient has more or less of these, up to 20, and sometimes 30. They are painful to the wearer, and odious to every spectator. At the approach of winter an eruptive fever happens to many in these countries: the eruptions principally infest the head, and when at the height an ichorous humour flows from them. In this state they are too tender to admit of being touched, and the matter running down the hairs mats them together; the skin by degrees, breaking, the ramifications of the capillary vessels following the course of the hair, or prolonged out of the skin, are increased to a vast length.

No method of relief is yet known; for if the discharge be checked, or the vessels cut off, the consequence is an increase of more miserable symptoms, and in the end death. Sennertus says, when all the morbid matter is thrown out of the body the plicæ fall off spontaneously. He further observes, that the only safe practice in this case is, to solicit the peccant matter to the hairs, to which it naturally tends; and that this is best answered by lotions of bear's-breech. Some say that a decoction of the herb club-moss, and its seeds, with which the head is to be washed, is a specific.

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Genus XCI. ICTERUS.

The *Jaundice*.

Icterus, *Lin.* 224. *Vog.* 306. *Boerh.* 918. *Junck.* 90.
Aurigo, *Sauv.* gen. 306. *Sag.* 132.
Cachexia icterica, *Hoffm.* III. 301.

Description. The jaundice first shows itself by a listlessness and want of appetite, the patient becomes dull, oppressed, and generally costive. These symptoms have continued but a very short time, when a yellow colour begins to diffuse itself over the *tunica albuginea*, or white part of the eye, and the nails of the fingers; the urine becomes high coloured, with a yellowish sediment capable of giving a yellow tinct to linen; the stools are whitish or gray. In some there is a most violent pain in the epigastric region, which is considerably increased after meals. Sometimes the patient has a continual propensity to sleep; but in others there is too great watchfulness; and sometimes the pain is so great, that though the patient be sleepy he cannot compose himself to rest. The pains come by fits; and most women who have had the jaundice and born children, agree, that they are more violent than labour-pains. As the disease increases, the yellow colour becomes more and more deep; an itching is felt all over the skin; and even the internal membranes of the viscera, the bones, and the brain itself, become tinged, as hath been shown from dissections, where the bones have been found tinged sometimes for years after the jaundice has been cured.

In like manner, all the secretions are affected with the yellow colour of the bile, which in this disease is diffused throughout the whole mass of fluids. The saliva becomes yellowish and bitter; the urine excessively high coloured, in such a manner as to appear almost black; nay, the blood itself is sometimes said to appear of a yellow colour when drawn from a vein; yet Dr Heberden says, that he never saw the milk altered in its colour, even in cases of very deep jaundice. In process of time the blood begins to acquire a tendency to dissolution and putrefaction; which is known by the patient's colour changing from a deep yellow to a black or dark yellow. Hæmorrhages ensue from various parts of the body, and the patients frequently die of an apoplexy; though in some the disease degenerates into an incurable dropsy; and there have not been wanting instances of some who have died of the dropsy after the jaundice itself had been totally removed. Icterus.

Causes. As the jaundice consists in a diffusion of the bile throughout the whole system, it thence follows, that whatever may favour the diffusion is also to be reckoned among the causes of jaundice. Many disputes have arisen concerning the manner in which the bile is introduced into the blood; but it is now generally agreed that it is taken up by the lymphatics of the gall-bladder and biliary ducts. Hence, a jaundice may arise from any thing obstructing the passage of the bile into the duodenum, or from any thing which alters the state of the lymphatics in such a manner as to make them capable of absorbing the bile in its natural state. Hence the jaundice may arise from scirrhi of the liver or other viscera pressing upon the biliary ducts, and obstructing the passage of the bile; from flatus distending the duodenum, and shutting up the entrance of the ductus communis choledochus into it; from the same orifice being plugged up by viscid bile, or other sordes; but by far the most frequent cause of jaundice is the formation of calculi, or more properly biliary concretions: for although they were long considered as being of a calcareous nature, yet more accurate experiments have now demonstrated, that they consist principally of a sebaceous matter; accordingly, while they are so light as to swim in water, they are also highly inflammable. These are found of almost all sizes, from that of a small pea to that of a walnut, or bigger: they are of different colours; and sometimes appear as if formed in the inward part by crystallization, but of lamellæ on the outer part; though sometimes the outward part is covered with rough and shining crystals, while the inward part is lamellated. These enter into the biliary ducts, and obstruct them, causing a jaundice, with violent pain for some time; and which can be cured by no means till the concretion is either passed entirely through the ductus communis or returned into the gall-bladder. Sometimes, in the opinion of many celebrated physicians, the jaundice is occasioned by spasmodic constrictions of the biliary ducts; but this is denied by others, and it is not yet ascertained whether these ducts are capable of being affected by spasm or not, as the existence of muscular fibres in them has not with certainty been discovered. It cannot, however, be denied, that violent fits of passion have often produced jaundice, sometimes temporary, but frequently permanent. This has been by some deemed a sufficient proof of the spasmodic contraction of the ducts; but their opponents supposed, that the agitation occasioned by the passion might push forward some biliary concretion into a narrow part of the duct, by which means a jaundice would certainly be produced, till the concretion was either driven backward or forward into the duodenum altogether. But even supposing the ducts themselves to be incapable of spasm, yet there can be no doubt that by a spasm of the intestines biliary concretions may be retained in the ducts; and

and indeed it is principally where the duct entering obliquely into the intestine forms as it were a species of valve that these concretions are retained.

In a very relaxed state of the body there is also an absorption of the bile, as in the yellow fever; and indeed in all putrid disorders there is a kind of yellowish tinct over the skin, though much less than in the true jaundice. The reason of this is, that in these disorders there is usually an increased secretion of bile, commonly of a thinner consistence than in a healthy state, while the orifices of the lymphatics are probably enlarged, and thus ready to absorb a fluid somewhat thicker than what they ought take up in a healthy state; but these disorders are of short duration in comparison with the real jaundice, which sometimes lasts for many years. These affections, however, cannot with propriety in any case be considered as real instances of jaundice; for, to constitute that disease, bile must not only be present in the blood, but wanting in the alimentary canal.

It is observable, that women are more subject to jaundice than men, which probably arises from their more sedentary life; for this, together with some of the depressing passions of the mind, is found to promote the accession of the disease, if not absolutely to produce it. Pregnant women also are frequently attacked by the jaundice, which goes off after their delivery.

Prognosis. As jaundice may arise from many different causes, some of which cannot be discovered during the patient's life, the prognosis must on this account be very uncertain. The only cases which admit of a cure are those depending upon biliary concretions, or obstructions of the biliary ducts by viscid bile; for the concretions are seldom of such a size that the ducts will not let them pass through, though frequently not without extreme pain. Indeed this pain, though so violent, and almost intolerable to the sick person, affords the best prognosis; as the physician may readily assure his patient that there is great hope of his being relieved from it. The coming on of a gentle diarrhœa, attended with bilious stools, together with the cessation of pain, are signs of the disease being cured. We are not, however, always to conclude, because the disease is not attended with acute pain, that it is therefore incurable; for frequently the passage of a concretion through the biliary ducts is accompanied only with a sensation of slight uneasiness.

Cure. The great object to be aimed at in the cure of jaundice is unquestionably the removal of the cause which obstructs the passage of bile into the intestines: But before this can be accomplished, practices are often necessary for alleviating urgent symptoms; which may be done sometimes by supplying the want of bile in the alimentary canal, sometimes by affording an exit for bilious matter from the general mass of blood, but most frequently by obviating the effects of distention and obstruction to the circulation in the system of the liver.

The measures to be employed for the removal of the obstruction must depend very much on the nature of the obstructing cause.

When the jaundice arises from indurated swellings or scirrhi of the viscera, it is absolutely incurable; nevertheless, as these cannot always be discovered, the physician ought to proceed in every case of jaundice as if it arose from calculi. The indications here are, 1. To dissolve the concretions; and, 2. To prevent their formation a second time. But unhappily the medical art has not yet afforded a solvent for biliary concretions. They cannot even be dissolved when tried out of the body either by acids or alkalies, or any thing but a mixture of oil of turpentine and spirit of wine; and these substances are by far too irritating to be given in sufficient quantity to affect a concretion in the biliary ducts. Boerhaave observes, that diseases of the liver are much more difficult to cure than those in any other part of the body; because of the difficulty there is in getting at the part affected, and the tedious and roundabout passage the blood has to it. The juice of common grass has indeed been recommended as a specific in the jaundice, but on no good foundation. Glisson observes, that black cattle are subject to biliary concretions when fed with hay or dried straw in winter, but are cured by the succulent grass in the spring; and Van Swieten tells a strange story of a man who cured himself of the jaundice by living almost entirely on grass, of which he devoured such quantities, that the farmers were wont to drive him out of their fields; but other practitioners have by no means found this in any degree effectual. The only method of cure now attempted in the jaundice is to expel the concretion into the intestines; for which vomits and exercise are the principal medicines. The former are justly reckoned the most efficacious medicines, as they powerfully shake all the abdominal and thoracic viscera; and thus tend to dislodge any obstructing matter that may be contained in them. But if there be a tendency to inflammation, vomits must not be exhibited till bleeding has been premised. We must also proceed with caution if the pain be very sharp; for in all cases where the disease is attended with violent pain, it will be necessary to allay it by opiates before the exhibition of an emetic. There is also danger, that, by a continued use of vomits, a concretion which is too large to pass, may be so impacted in the ducts that it cannot even be returned into the gall-bladder, which would otherwise have happened. In all cases, therefore, if no relief follows the exhibition of the second or third emetic, it will be prudent to forbear their farther use for some time.

Of all kinds of exercise, that of riding on horseback is most to be depended upon in this disease. It operates in the same manner with vomits, namely, by the concussion it gives to the viscera; and therefore the cautions necessary to be observed in the use of vomits are also necessary to be observed in the use of riding. Cathartics also may be of service, by cleansing the *primæ viæ*, and soliciting a discharge of the bile into the intestines; but they must not be of too drastic a nature, else they may produce incurable obstructions, by bringing forward concretions that are too large to pass. Anodynes and the warm bath are serviceable by their relaxing quality; and there can be no doubt, that, from acting as powerful antispasmodics, they often give an opportunity for the discharge of concretions by very slight causes, when they would otherwise be firmly retained. Soap has been supposed to do service

Dysæsthesiæ. as a solvent; but this is now found to be a mistake, and it acts in no other way than as a relaxant or as a gentle purgative.

But when all means of relief fail, as in cases of scirrhus, we can then only attempt to palliate the symptoms, and preserve the patient's life as long as possible. This is best accomplished by diuretics; for thus a great quantity of bilious matter is evacuated, and the system is freed from the bad consequences which ensue on its stagnation in the habit. But even this is by no means equal to the common evacuation by stool; nor can all the attempts to supply the want of bile in the intestines by bitters and other stomachics restore the patient to his wonted appetite and vigour. If the pain be very violent, we must on all occasions have recourse to opiates; or if the blood has acquired a tendency to dissolution, it must be counteracted by proper antiseptics.

If the disease goes off, its return must be prevented by a course of tonic medicines, particularly the cinchona and antiseptics: but we can by no means be certain that the jaundice will not return, and that at any interval; for there may be a number of concretions in the gall-bladder, and though one has passed, another may very quickly follow, and produce a new fit of jaundice; and thus some people have continued to be affected with the distemper, at short intervals, during life.

In the East Indies, mercury has been lately recommended as exceedingly efficacious in disorders of the liver, especially those which follow intermitting and remitting fevers. Dr Monro, in his Observations on the means of preserving the health of soldiers, acquaints us, that he has seen some icteric cases which, he thought, received benefit from taking a few grains of the submurias hydrargyri at night, and a purge next morning; and this repeated two or three times a-week.

Infants are subject to a temporary jaundice, commonly called the *gum*, soon after birth; the cause of which is not well understood. It differs remarkably from the common jaundice; as, in the latter, the disease is first discoverable in the white of the eyes; but though the skin of infants in the gum is all over yellow, their eyes always remain clear. The disorder goes off spontaneously, or by the use of a gentle purgative or two.

357 Class IV. LOCALES.

Vitia, *Sauv.* Class I. *Lin.* Class XI. *Vog.* Class X. *Sag.* Class I.
Plagæ, *Sag.* Class II.
Morbi organici Auctorum.

358 Order I. DYSÆSTHESIÆ.

Dysæsthesiæ, *Sauv.* Class VI. Ord. I. *Sag.* Class IX. Ord. I.

359 Genus XCII. CALIGO.

The *Cataract.*

Caligo, *Sauv.* gen. 153. *Vog.* 288. *Sag.* gen. 259.
Cataracta, *Lin.* 109.

A *cataract* is an obstruction of the pupil, by the interposition of some opaque substance which either diminishes or totally extinguishes the sight. It is generally an opacity in the crystalline humour. In a recent or beginning *cataract*, the same medicines are to be used as in the *gutta serena*; and they will sometimes succeed. But when this does not happen, and the cataract becomes firm, it must be couched, or rather extracted; for which operation, see Surgery.—Dr Buchan says he has resolved a recent cataract by giving the patient some purges with calomel, keeping a poultice of fresh hemlock constantly upon the eye, and a perpetual blister on the neck.

There is, however, but little reason to suppose that these practices will frequently succeed. A resolution can only be effected here by an absorption of the opaque matter; and where this is possible, there is perhaps a better chance of its being effected by the agency of the electric fluid than by any other means. For this purpose electricity is chiefly applied under the form of the *electric aura*, as it has been called; but even this is very rarely successful.

Genus XCIII. AMAUROSIS. 360

The *Gutta Serena.*

Amaurosis, *Sauv.* gen. 155. *Lin.* 110. *Vog.* 238. *Sag.* 261.
Amblyopia, *Lin.* 108. *Vog.* 236.

Amaurosis. A *gutta serena* is an abolition of the sight without any apparent cause or fault in the eyes. In every case it depends on an affection of some part of the optic nerve. But the affections which may produce this disease are of different kinds. When it is owing to a decay or wasting of the optic nerve, it does not admit of a cure; but when it proceeds from a compression of the nerves by redundant humours, these may be in some measure drained off, and the patient relieved. For this purpose, the body must be kept open with the laxative mercurial pills. If the patient be young, and of a sanguine habit, he may be bled. Cupping with scarifications on the back part of the head will likewise be of use. A running at the nose may be promoted by volatile salts, stimulating powders, &c. But the most likely means of relieving the patient, are issues or blisters kept open for a long time on the back part of the head, behind the ears, or on the neck; which have been known to restore sight even after it had been for a considerable time lost.—Should these fail, recourse must be had to a mercurial salivation; or, what will perhaps answer the purpose better, 12 grains of the corrosive sublimate mercury may be dissolved in an English pint and a half of brandy, and a table spoonful of it taken twice a-day, drinking half a pint of the decoction of sarsaparilla after it.—Of late electricity has been much celebrated as efficacious, when no other thing could do service; and here it has in some degree the same chance of success as in other cases of insensibility, depending on an affection of the nerves, in some of which it has certainly in particular cases been of use.

In the amaurosis, Dr Porterfield observes, that it is of the utmost consequence to know of how long standing the disease has been; which is not always easily done if one eye only be infected. This is a very essential

D sthe- tial point; because an amaurosis of long standing is altogether incurable. Mr Boyle mentions the case of a man who had a cataract for several years without knowing it himself, though others did. He discovered it at last by happening to rub his sound eye, and was surprised to find himself in the dark. When a person, therefore has a gutta serena only in one of the eyes, he may think that the eye has but lately lost the power of sight; though this perhaps has been the case for several years. On the other hand, he may imagine that a recent disease of this kind is really of long standing. But by inquiring at what time he first became subject to mistakes in all actions that require the distance to be exactly distinguished, as in pouring liquor into a glass, snuffing a candle, or threading a needle, we may discover the age of the disease, and thence be assisted to form a more just prognostic with respect to its cure. Dr Porterfield gives an instance of his conjecturing in this manner concerning the case of a young lady who had discovered a loss of sight in one of her eyes only the day before. The disease was thought to be of long standing; but as the doctor found that she had only been subject to mistakes of the kind above mentioned for about a month, he drew a favourable prognostic, and the disease was cured.

61 GENUS XCIV. DYSOPIA.

DEPRAVED VISION.

Amblyopia, *Sauv.* gen. 154. *Sag.* 258.

There are several species referred to this genus by Dr Cullen, viz.

1. *Dysopia* TENEBRARUM; 2. *Dysopia* LUMINIS.—The former of these is properly the *nyctalopia*, or night-blindness, of ancient authors. But amongst both the Greek and Latin writers, there is a direct opposition in the use of this word *nyctalopia;* some saying it signifies "those who *cannot* see by night," and others express by it "those who cannot see during the day, but during the *night*."—The difference in the account of this disorder, as to its appearing in the night or in the day, is reconciled by considering it as of the intermitting kind: the difference then will consist in the different times of its approach; so it may be called *periodical blindness.* Intermittents appearing in a variety of modes, and the success of cinchona in some instances of this sort of blindness, both favour the opinion of its being an intermittent disease of the eyes; and this view has accordingly been taken of it by some late writers, particularly in some papers in the London Medical Observations, and Medical Transactions.

3. *Dysopia PROXIMORUM* (*Presbytia,*) or the defect of those who *see only at too great distance.* 4. *Dysopia DISSITORUM* (*Myopia*), or the defect of those who are *shortsighted.*—These are disorders which depend on the original structure or figure of the eye, therefore admit of no cure. The inconveniences arising from them may, however, be in some measure remedied by the help of proper glasses. The former requires the aid of a convex, and the latter of a concave glass.

5. *Dysopia LATERALIS;* a defect by which objects cannot be viewed distinctly but in an oblique position.—Thus, in viewing an object placed on the left, they turn their face and eyes to the right, and *vice versa.*—This disorder may proceed from various causes both natural and accidental, some of which admit of no remedy. If it be occasioned by a partial adhesion of the eyelids, the hand of the surgeon is required: if by a transverse position of the pupil, some mechanical contrivance is necessary. If it be owing to an *albugo* covering part of the pupil, or to a film rendering a portion of the cornea opaque, the remedies for these affections are to be here applied.

GENUS XCV. PSEUDOBLEPSIS. 362

IMAGINARY VISION of Objects which do not exist.

Suffusio, *Sauv.* gen. 217. *Sag.* 329.
Phantasma, *Lin.* 73. *Sag.* 289.

This very often takes place when the body is diseased, and then the patient is said to be delirious. Sometimes, however, in these cases, it does not amount to delirium; but the person imagines he sees gnats or other insects flying before his eyes; or sometimes, that every thing he looks at has black spots in it, which last is a very dangerous sign. Sometimes also sparks of fire appear before the eyes; which appearances are not to be disregarded, as they frequently precede apoplexy or epilepsy. Sometimes, however, people have been affected in this manner during life without feeling any other inconvenience. Such a disorder can rarely if ever be cured.

GENUS XCVI. DYSECOEA. 363

DEAFNESS, or *Difficulty of Hearing.*

GENUS XCVII. PARACUSIS. 364

Depravation of HEARING.

Paracusis, *Sauv.* gen. 159. *Sag.* 265.
Syrigmus, *Sauv.* gen. 219. *Sag.* 231.

Paracusis.

The functions of the ear may be injured by wounds, ulcers, or any thing that hurts its fabric. The hearing may likewise be hurt by excessive noise; violent colds in the head; fevers; hard wax, or other substances sticking in the cavity of the ear; too great a degree of moisture or dryness of the ear. Deafness is very often the effect of old age, and is incident to most people in the decline of life. Sometimes it is owing to an original fault in the structure or formation of the ear itself. When this is the case it admits of no cure; and the unhappy person not only continues deaf, but generally likewise dumb, for life.

When deafness is the effect of wounds or ulcers of the ears, or of old age, it is not easily removed. When it proceeds from cold applied to the head, the patient must be careful to keep his head warm, especially in the night; he should likewise take some gentle purges, and keep his feet warm, and bathe them frequently in lukewarm water at bedtime. When deafness is the effect of a fever, it generally goes off after the patient recovers. If it proceed from dry wax sticking in the ears, it may be softened by dropping oil into them; afterwards they must be syringed with warm milk and water.

If deafness proceeds from dryness of the ears, which may

Dysæsthesiæ.

may be known by looking into them, half an ounce of the oil of sweet almonds, and the same quantity of camphorated spirit of wine, or tincture of asafœtida, may be mixed together, and a few drops of it put into the ear every night at bedtime, stopping them afterwards with a little wool or cotton. Some, instead of oil, put a small slice of the fat of bacon into each ear, which is said to answer the purpose very well.—When the ears abound with moisture, it may be drained off by an issue or seton, which should be made as near the affected parts as possible.

Some, for the cure of deafness, recommend the gall of an eel mixed with spirit of wine, to be dropped into the ear; others, equal parts of Hungary water and spirit of lavender. Etmuller extols amber and musk; and Brookes says, he has often known hardness of hearing cured by putting a grain or two of musk into the ear with cotton wool. Where, however, an application with considerable stimulant power is necessary, camphorated oil, with the addition of a few drops of volatile alkaline spirit, may be considered as one of the best. It is proper, however, to begin with a small quantity of the alkali, increasing it as the ear is found to bear it. In some instances, where deafness depends on a state of insensibility in the nerves, electricity, particularly under the form either of sparks, or of the electric aura, has been employed with great success. Great benefit has also in some cases been derived from galvanism. But these and other applications must be varied according to the cause of the disorder.

Though such applications may sometimes be of service, yet they much oftener fail, and frequently they do hurt. Neither the eyes nor ears ought to be tampered with; they are tender organs, and require a very delicate touch. For this reason, what we would chiefly recommend in deafness, is to keep the head warm. From whatever cause this disorder proceeds, this is always proper; and more benefit has often been derived from it alone, in the most obstinate cases of deafness, than from any medicines whatever.

365

Genus XCVIII. ANOSMIA.

Defect of Smelling.

Anosmia, *Sauv.* gen. 156. *Lin.* 113. *Vog.* 248. *Sag.* 262.

Causes. Morbid affections in the sense of smelling, may be considered with respect to their causes, as arising from one of two sources; either from some organic affection of the parts here principally concerned, or from a mere atonic state of the parts without any obvious affection. The sense of smelling may be diminished or destroyed by various diseases of the parts; as, the moisture, dryness, inflammation or suppuration of that membrane which lines the inside of the nose, commonly called the *olfactory membrane;* the compression of the nerves which supply this membrane, or some fault in the brain itself at their origin. A defect, or too great a degree of solidity, of the small spongy bones of the upper jaw, the caverns of the forehead, &c. may likewise impair the sense of smelling. It may also be injured by a collection of fetid matter in those caverns, which keeps constantly exhaling from them. Few things are more hurtful to the sense of smelling than taking great quantities of snuff.

Cure. When the nose abounds with moisture, after gentle evacuations, such things as tend to take off irritation and coagulate the thin sharp serum may be applied; as the oil of anise mixed with fine flour, camphire dissolved in oil of almonds, &c. The vapours of amber, frankincense, gum-mastic, and benzoin, may likewise be received into the nose and mouth. For moistening the mucus when it is too dry, some recommend snuff made of the leaves of marjoram, mixed with oil of amber, and aniseed; or a sternutatory of calcined sulphate of zinc, 12 grains of which may be mixed with two ounces of marjoram-water and filtrated. The steam or vapour of vinegar thrown upon hot iron received up the nostrils is likewise of use for softening the mucus, opening obstructions, &c.

If there be an ulcer in the nose, it ought to be dressed with some emollient ointment, to which, if the pain be very great, a little laudanum may be added. If it be a venereal ulcer, it is not to be cured without mercury. In that case, the solution of the corrosive sublimate in brandy may be taken, as directed in the gutta serena. The ulcer ought likewise to be washed with it; and the fumes of cinnabar may be received up the nostrils.

If there be reason to suspect that the nerves which supply the organs of smelling are inert or want stimulating, volatile salts, strong snuffs, and other things which occasion sneezing, may be applied to the nose. The forehead may likewise be anointed with balsam of Peru, to which may be added a little of the oil of amber.

Ageustia.

Genus XCIX. AGEUSTIA.

Defect of Tasting.

Ageustia, *Sauv.* gen. 157. *Sag.* 263.
Ageustia, *Lin.* 114.
Apogeusis, *Vog.* 449.

Cause. This disease also may arise either from an organic affection, or an atonic state of the parts. The taste may be diminished by crusts, filth, mucus, aphthæ, pellicles, warts, &c. covering the tongue; it may be depraved by a fault of the saliva, which, being discharged into the mouth, gives the same sensation as if the food which the person takes had really a bad taste; or it may be entirely destroyed by injuries done to the nerves of the tongue and palate. Few things prove more hurtful either to the sense of tasting or smelling than obstinate colds, especially those which affect the head.

Cure. When the taste is diminished by filth, mucus, &c. the tongue ought to be scraped, and frequently washed with a mixture of water, vinegar, and honey, or some other detergent. When the saliva is vitiated, which seldom happens unless in fevers or other diseases, the curing of the disorder is the cure of this symptom. To relieve it, however, in the mean time, the following practices may be of use: if there be a bitter taste, it may be taken away by vomits, purges, and other things which evacuate bile: what is called a *nidorous taste*, arising from putrid humours, is is corrected by the juice of citrons, oranges, and other acids; a salt taste is cured by plentiful dilution with watery liquors: an acid taste is destroyed by absorbents and alkaline salts, as powder of oyster-shells, salt of wormwood, &c.

When the sensibility of the nerves which supply the organs of taste is diminished, the chewing of horse-radish, and of other stimulating substances, will help to recover it.

367 Genus C. ANÆSTHESIA.

Defect of the Sense of Feeling.

Sauv. gen. 161. *Lin.* 218. *Vog.* 267.

Causes, &c. This sense may be hurt by any thing that obstructs the nervous system, or prevents its being regularly conveyed to the organs of touching, as pressure, extreme cold, &c. It may likewise be hurt by too great a degree of sensibility, when the nerve is not sufficiently covered by the cuticle or scarf-skin, or where there is too great a tension of it, or it is too delicate. Whatever disorders the functions of the brain and nerves, hurts the sense of touching. Hence it appears to proceed from the same general causes as palsy and apoplexy, and requires nearly the same method of treatment.

In a *stupor*, or defect of touching, which arises from an obstruction of the cutaneous nerves, the patient must first be purged; afterwards such medicines as excite the action of the nerves, or stimulate the system, may be used. For this purpose, the spirit of hartshorn, either by itself or combined with essential oils, horse-radish, &c. may be taken inwardly; the disordered parts, at the same time, may be frequently rubbed with fresh nettles or spirit of sal ammoniac. Blisters and sinapisms applied to the parts will likewise be of use; and also warm bathing, especially in the natural hot baths.

368 Order II. DYSOREXIÆ.

Sect. I. *APPETITUS ERRONEI.*

Morositates, *Sauv.* Class VIII. Order II. *Sag.* Class. XIII. Order II.
Pathetici, *Lin.* Class. V. Order II.
Hyperæstheses, *Vog.* Class VII.

369 Genus CI. BULIMIA.

Insatiable Hunger, or *Canine Appetite.*

Bulimia, *Sauv.* gen. 223. *Lin.* 79. *Sag.* gen. 335.
Bulimus, *Vog.* 296.
Addephagia, *Vog.* 297.
Cynorexia, *Vog.* 298.

This disease is commonly owing to some fault in the stomach, by which the aliments are thrown out too soon; and unless the person be indulged in his desire for eating, he frequently falls into fainting fits. Sometimes it is attended with such a state of the stomach, that the aliment is rejected by vomit almost immediately after being swallowed; after which the appetite for food returns as violent as ever. But there

are many circumstances which seem to render it probable that it more frequently arises from a morbid condition of the secreted fluid poured into the stomach, by means of which the aliment is dissolved. When the activity of this fluid is morbidly increased, it will both produce too sudden a solution of the solid aliment, and likewise operate as a powerful and peculiar stimulus to the stomach, giving an uneasy sensation, similar to that which takes place in natural hunger. Such things are proper for the cure as may enable the stomach to perform its office: chalybeates and other tonics will generally be proper. In some, brandy drunk in a morning has been useful; and frequent smoking tobacco has relieved others. Oil, fat meat, pork, opiates, and in short every thing which in a sound person would be most apt to pall the appetite, may also be used as temporary expedients, but cannot be expected to perform a cure. In some, the pylorus has been found too large; in which case the disease must have been incurable.

Genus CII. POLYDIPSIA. 370

Excessive Thirst.

Polydipsia, *Sauv.* gen. 224. *Lin.* 80. *Vog.* 275. *Sag.* 336.

This is almost always symptomatic; and occurs in fever, dropsy, fluxes, &c. The cure is very generally obtained only by the removal of the primary disease; and it is best palliated by the gradual introduction of diluents: But when these are contraindicated, it may often be successfully obviated by such articles taken into the mouth as have effect in augmenting the flow of saliva.

Genus CIII. PICA. 371

Longing, or *False Appetite.*

Pica, *Sauv.* gen. 222. *Sag.* 334.
Citta, *Lin.* 78.
Allotriophagia, *Vog.* 299.
Malacia, *Vog.* 300.

The pica is also very generally symptomatic of other diseases, as of worms, chlorosis, pregnancy, &c; and is therefore chiefly to be combated by the removal of the primary affection. It may, however, be observed, that peculiar longings occurring in certain diseases, as for example in fevers, often point out a natural cure. The indulgence of such appetites to a moderate degree is seldom productive of any inconvenience, and often followed by the best consequences.—Hence there are some practitioners who think that such craving should very generally be indulged; particularly when the patient can assign no reason whatever for such particular longings, but is merely prompted by an uncommon and inexplicable desire.

Genus CIV. SATYRIASIS. 372

Satyriasis, *Sauv.* gen. 228. *Lin.* 81. *Sag.* 340.

Satyriasis is a violent desire of venery in men, even so that reason is depraved by it. The pulse is quick, and the breathing short; the patient is sleepless, thirsty, and

Dysorexiæ. and loathes his food; the urine is evacuated with difficulty, and a fever soon comes on. These symptoms, however, are probably not so much the consequence of satyriasis, as merely concomitant effects resulting from the same cause. And indeed this affection is most frequently the concomitant of a certain modification of insanity. The nature and cause of this affection are in most instances very little ascertained; but as far as we are acquainted with the treatment, it agrees very much with the affection next to be mentioned, which, of the two, is the most common occurrence.

373 GENUS CV. NYMPHOMANIA.

FUROR UTERINUS.

Nymphomania, *Sauv.* 229. *Sag.* 341.
Satyriasis, *Lin.* 81.

The *furor uterinus* is in most instances either a species of madness or a high degree of hysterics. Its immediate cause is a preternatural irritability of the uterus and pudenda of women (to whom the disorder is proper), or an unusual acrimony of the fluids in these parts.—Its presence is known by the wanton behaviour of the patient; she speaks and acts with unrestrained obscenity; and as the disorder increases, she scolds, cries, and laughs, by turns. While reason is retained, she is silent, and seems melancholy, but her eyes discover an unusual wantonness. The symptoms are better and worse until the greatest degree of the disorder approaches, and then by every word and action her condition is too manifest.—In the beginning a cure may be hoped for; but if it continue, it degenerates into a mania.—In order to the cure, blood-letting is commonly recommended in proportion to the patient's strength. Camphor in doses of 15 or 20 grains, with nitre, and small doses of the tincture of opium, should be repeated at proper intervals. Some venture to give cerusa acetata in doses from three to five grains. Besides bleeding, cooling purges should also be repeated in proportion to the violence of symptoms, &c. What is useful in maniacal and hypochondriac disorders, is also useful here, regard being had to sanguine or phlegmatic habits, &c. When the delirium is at the height, give opiates to compose; and use the same methods as in a phrenitis or a mania. Injections of barley-water, with a small quantity of hemlock-juice, according to Riverius, may be frequently thrown up into the uterus; this is called *specific*; but matrimony, if possible, should be preferred. For although this cannot be represented as a cure for the disease when in an advanced state, yet there is reason to believe that it has not unfrequently prevented it where it would otherwise have taken place.

374 GENUS CVI. NOSTALGIA.

Vehement DESIRE *of* REVISITING *one's* COUNTRY.

Nostalgia, *Sauv.* gen. 226. *Lin.* 83. *Sag.* 338.

This is to be reckoned a species of melancholy; and unless it be indulged, it very commonly proves not only incurable but even fatal. Although it cannot be considered as altogether peculiar to any nation, yet it is observed to be much more frequent with some than with others; and it has particularly been remarked among Swiss soldiers in the service of foreign states. Nostalgia.

SECT. II. *APPETITUS DEFICIENTES.*

Anepithymiæ, *Sauv.* Class VI. Ord. II. *Sag.* IX. Ord II.
Privativi, *Lin.* Class VI. Order III.
Adynamiæ, *Vog.* Class VI.

GENUS CVII. ANOREXIA. 375

Want of APPETITE.

Anorexia, *Sauv.* gen. 162. *Lin.* 116. *Vog.* 279. *Sag.* 268.

The anorexia is symptomatic of many diseases, but seldom appears as a primary affection; and it is very generally overcome only by the removal of the affection on which it depends.

GENUS CVIII. ADIPSIA. 376

Want of THIRST.

Adipsia, *Sauv.* gen. 162. *Lin.* 117. *Vog.* 281. *Sag.* 269.

This by Dr Cullen is reckoned to be always symptomatic of some distemper affecting the *sensorium commune.*

GENUS CIX. ANAPHRODISIA. 377

Impotence to VENERY.

Anaphrodisia, *Sauv.* gen. 164. *Sag.* 270.
Atecnia, *Lin.* 119.
Agenesia, *Vog.* 283.

For this, see the article IMPOTENCE in the alphabetical order.

ORDER III. DYSCINESIÆ. 378

GENUS. CX. APHONIA. 379

Loss of VOICE.

Aphonia, *Sauv.* gen. 166. *Lin.* 115. *Vog.* 253. *Sag.* 272.

The loss of voice may proceed from various causes. If one of the recurrent nerves, which are formed by the *par vagum* and the *nervus accessorius*, and reach the larynx, be cut, the person is capable of only as it were a half-pronunciation; but if both be cut, the speech and voice are both lost. The loss of speech happening in hysteric patients is also called *aphonia;* but more properly that loss of speech is thus named which depends on some fault of the tongue.

Since the motion of any part is destroyed, or lessened at least, by the interception of the nervous fluid in its passage thither, and since the nerves destined for the motion of the tongue arise principally from the fifth pair, it appears that the seat of this disorder is in the fifth pair of nerves, and that the immediate cause is inesiæ. Mutitas.

is a diminution or total destruction of the nervous power in them. Hence a palsy of the tongue, which is either antecedent or subsequent to hemiplectic or apoplectic disorders, demand our utmost attention.

If an aphonia appears alone, it generally bespeaks an approaching hemiplegia or apoplexy; but if it succeed these disorders, and is complicated with a weak memory and a sluggishness of the mental powers, it threatens their return. That aphony usually terminates the best which proceeds from a stagnation of serous humours compressing the branches of the fifth pair of nerves, which run to the tongue; but it is no less afflictive to the patient, and is very obstinate of cure.

Other causes of this disorder are, the striking in of eruptions on the skin, a congestion of blood in the fauces and tongue, obstructed periodical evacuations in plethoric habits, spasmodic affections, worms, a crumb of bread falling into the larynx, fear, too free an use of spirituous liquors; also whatever destroys the ligaments which go from the arytænoid to the thyroid cartilages, will destroy the voice.

The *prognostics* vary according to the cause. That species which is owing immediately to spasms, soon gives way on the removal of them. If a palsy of the tongue be the cause, it is very apt to return, though relieved, but often continues incurable.

In order to the *cure*, we must endeavour first to remove whatever obstructs the influx of the nervous fluid into the tongue, and secondly to strengthen the weak parts. These general intentions, in all cases, being regarded, the particular causes must be removed by remedies accommodated to each.

If worms be the cause, antispasmodics may give present relief; but the cure depends on the destruction or expulsion of the animals themselves. In case of a congestion of blood about the head, bleeding and nitrous medicines are to be used.—That species of aphony which remains after the shock of an hemiplegia or apoplexy, requires blisters to be applied to the nape of the neck; if spasmodic constrictions about the fauces and tongue be the cause, external paregorics are of the greatest service, anodyne antispasmodics may be laid under the tongue, and the feet bathed in warm water; carminative clysters also are useful.—When a palsy of the tongue produces this complaint, evacuations, according to the patient's habit, must be made, and warm nervous medicines must be externally applied, and internally administered; blisters also should be placed between the shoulders.—In case of repelled cuticular eruptions, sudorifics should be given, and the patient's drink should be warm. The spiritus ammoniæ succinatus, or vinum antimonii, may be employed either in combination with other articles, or by themselves, and given at proper distances of time, in the patient's drink, or on a bit of sugar.—Sometimes the serum flows so rapidly to the fauces and adjacent parts, in a salivation; as to deprive the patient of all power to speak; in this case diaphoretics and laxatives, with a forbearance of all mercurials, are the speediest remedies.

380 Genus CXI. MUTITAS.

Dumbness.

Mutitas. *Sauv.* gen. 165. *Vog.* 257. *Sag.* 271.

Dumb people are generally born deaf; in which case the distemper is incurable by medicine: though even such people may be taught not only to read and write, but also to speak and understand what others say to them. From some observations on the method in which this has been accomplished, we may refer the reader to the article Dumbness, in the alphabetical order. But in these cases, admitting of cure in the manner above alluded to, the dumbness proceeds principally, if not solely, from the deafness. For when it proceeds from a defect of any of the organs necessary for speech, the tongue for instance, it is always incurable; but if it arise from a palsy, the medicines applicable in that case will sometimes restore the speech.

Genus CXII. PARAPHONIA. 381

Change in the Sound of the Voice.

Paraphonia, *Sauv.* gen. 168.
Cacophonia, *Sag.* 274.
Raucedo, *Lin.* 146.
Raucitas, *Vog.* 252.
Asaphia, &c. *Vog.* 250, 251, 254, 255, 256.

The voice may be changed from various causes. In males it becomes much more hard about the time of puberty; but this can by no means be reckoned a disease. In others it proceeds from a catarrh, or what we call a *cold;* it arises also from affections of the nose and palate, as polypi, ulcers, &c. in which case the cure belongs properly to Surgery. In some it arises from a laxity of the *velum pendulum palati* and glottis, which makes a kind of snoring noise during inspiration. The cure of this last case is to be attempted by tonics and such other medicines as are of service in diseases attended with laxity.

Genus CXIII. PSELLISMUS. 382

Defect in Pronunciation.

Psellismus, *Sauv.* gen. 167. *Lin.* 139. *Sag.* 273.
Traulotis, &c. *Vog.* 258, 259, 260, 261.

Of this disease (if such it may be called), there are many different kinds. Some cannot pronounce the letter S; others labour under the same difficulty with R, L, M, K, &c.; while some who can with sufficient ease pronounce all the letters, yet repeat their words, or the first syllables of them, in such a strange manner, that they can scarce be understood. Very frequently these defects arise entirely from habit, and may then be got the better of by those who have the resolution to attempt it; as we are told that Demosthenes the celebrated orator got the better of a habit of stammering by declaiming with pebbles in his mouth. Sometimes, however, pronunciation may be impeded by a wrong conformation of the tongue or organs of speech; and then it cannot by any pains whatever be totally removed.

Genus CXIV. STRABISMUS. 383

Squinting.

Strabismus, *Sauv.* gen. 116. *Lin.* 304. *Vog.* 514. *Sag.* 222.

 Description

Dyscinesiæ. Strabismus.

Description. This disease shows itself by an uncommon contraction of the muscles of the eye; whereby the axis of the pupil is drawn towards the nose, temples, forehead, or cheeks, so that the person cannot behold an object directly.

Causes, Prognosis, &c. I. This disease may proceed from custom and habit; while in the eye itself, or in its muscles, nothing is preternatural or defective.

Thus children by imitating those that squint, and infants by having many agreeable objects presented to them at once, which invite them to turn one eye to one and the other eye to another, do frequently contract a habit of moving their eyes differently, which afterwards they cannot so easily correct. Infants likewise get a custom of squinting by being placed obliquely towards a candle, window, or any other agreeable object capable of attracting their sight: for though, to see the object, they may at first turn both eyes towards it; yet, because such an oblique situation is painful and laborious, especially to the most distant eye, they soon relax one of the eyes, and content themselves with examining it with the eye that is next it; whence arises a diversity of situation and a habit of moving the eyes differently.

In this case, which may admit of a cure if not too much confirmed, it is evident, that objects will be seen in the same place by both eyes, and therefore must appear single as to other men; but because, in the eye that squints, the image of the object to which the other eye is directed falls not on the most sensible and delicate part of the retina, which is naturally in the axis of the eye, it is easy to see that it must be but faintly perceived by this eye. Hence it is, that while they are attentive in viewing any object, if the hand be brought before the other eye, this object will be but obscurely seen, till the eye change its situation and have its axis directed to it; which change of situation is indeed very easy for them, because it depends on the muscles of the eyes, whose functions are entire; but, by reason of the habit they have contracted of moving their eyes differently, the other eye is at the same time frequently turned aside, so that only one at a time is directed to this object.

II. The *strabismus* may proceed from a fault in the first conformation, by which the most delicate and sensible part of the retina is removed from its natural situation, which is directly opposite to the pupil, and is placed a little to a side of the axis of the eye; which obliges such people to turn away the eye from the object they would view, that its picture may fall on this most sensible part of the organ.

When this is the case, the disease is altogether incurable, and the phenomena that arise therefrom differ in nothing from the phenomena of the former case, excepting only that here, 1. The object to which the eye is not directed will be best seen; which is the reverse of what happens when this disease arises barely from habit and custom. 2. No object will appear altogether clear and distinct: for all objects to which the eye is directed, by having their image painted in the retina at the axis of the eye, where it is not very sensible, will be but obscurely seen; and objects that are placed so far to a side of the optic axis as is necessary for making their image fall on the most sensible and delicate part of the retina, must appear a little confused, because the several pencils of rays that come therefrom fall too obliquely on the crystalline to be accurately collected in so many distinct points of the retina; though it must be acknowledged, that this confusion will, for the most part, be so small as to escape unobserved.

III. This disease may proceed from an oblique position of the crystalline, where the rays that come directly to the eye from an object, and that ought to converge to the point of the retina, which is in the axis of the eye, are, by reason of the obliquity of the crystalline, made to converge to another point on that side of the visual axis where the crystalline is most elevated; and therefore the object is but obscurely seen, because its image falls not on the retina at the axis of the eye, where it is most sensible: But the rays that fall obliquely on the eye, will after refraction, converge to this most sensible part of the retina; and, by converging there, must impress the mind with a clear idea of the object from whence they came. It is for this reason that the eye never moves uniformly with the other, but turns away from the object it would view, being attentive to the object to which it is not directed. When this is the case, it is in vain to expect any good from medicine.

The symptoms which naturally arise from it are, 1. The object to which the eye is directed will be but faintly seen, because its image falls on the retina where it is not very sensible. 2. The object to which the eye is not directed, by having its image painted on the retina at the axis of the eye, will be clearly perceived. But, 3d. This same object must appear somewhat indistinct, because the pencils of rays that flow from it are not accurately collected in so many distinct points in the retina, by reason of their oblique incidence on the crystalline. 4. It must be seen, not in its proper place, but thence translated to some other place situated in the axis of vision. And, 5. Being thus translated from its true place, where it is seen by the other eye that does not squint, it must necessarily appear double; and the distance between the places of its appearance will be still greater, if the crystalline of the other eye incline to the contrary side.

IV. This disease may arise from an oblique position of the cornea; which, in this case, is generally more arched and prominent than what it is naturally.

When the eye has this conformation, no object to which it is directed can be clearly seen, because its image falls not on the retina at the axis of the eye; and therefore the eye turns aside from the object it would view, that its image may fall on the most sensible part of the retina.

When the strabismus proceeds from this cause, the prognostic and the phenomena that attend it will be much the same as in the case immediately preceding; from which nevertheless it may be distinguished by the obliquity of the cornea, which is manifest to the senses, and if the cornea be also more arched and prominent than what it is naturally, which is commonly the case, the eye will also be short-sighted.

V. This want of uniformity in the motions of our eyes, may arise from a defect, or any great weakness, or

Dyscinesiæ. or imperfection, in the sight of both or either of the eyes; and this, according to Dr Porterfield, is the most common cause of this disease. The prognostic in this case is the same with that of the disease from which it proceeds.

VI. Another cause from which the strabismus may proceed, lies in the muscles that move the eye. When any of those muscles are too short or too long, too tense or too lax, or are seized with a spasm or paralysis, their equilibrium will be destroyed, and the eye will be turned towards or from that side where the muscles are faulty.

In this case, the disease frequently yields to medicine, and therefore admits of favourable prognostic; excepting only when, by a fault in the first conformation, any of the muscles are longer or shorter than their antagonist; in which case, if ever it should happen, no medicine can be of any use.

As to what concerns the optical phænomena, they are the same here as in case first: only when the disease commences not till, by custom and habit, the uniform motion of the eyes has been rendered necessary, all objects do for some time appear double; but in time they appear single.

Lastly, This want of uniformity in the motions of our eyes may proceed from a preternatural adhesion or attachment to the eyelids: of this we have an instance in Langius. And that the same thing may also be occasioned by a tumour of any kind within the orbit, pressing the eye aside, and restraining it from following the motions of the other, is so evident, that instances need not be brought to prove it. Here also the case may admit of a favourable prognostic; and as for what concerns the optical phænomena, they must be the same as in the case immediately preceding.

The *cure*, in confirmed cases, is to be effected by mechanical contrivances, by which the person may be obliged to look straight upon objects, or not see them at all; or at least that he may see with uneasiness and confusedly when he squints. In the 68th volume of the Philosophical Transactions we have an account of a confirmed case of squinting of a very uncommon kind. The patient was a boy of five years old, and viewed every object which was presented to him with but one eye at a time. If the object was presented on his right side, he viewed it with his left eye; and if it was presented on his left side, he viewed it with his right eye. He turned the pupil of that eye which was on the same side with the object in such a direction that the image of the object might fall on that part of the bottom of the eye where the optic nerve enters it. When an object was held directly before him, he turned his head a little to one side, and observed it with but one eye, viz. that most distant from the object, turning away the other in the manner above described; and when he became tired of observing it with that eye, he turned his head the contrary way, and observed it with the other eye alone, with equal facility; but never turned the axis of both eyes on it at the same time. He saw letters which were written on bits of paper, so as to name them with equal ease, and at equal distances, with one eye as with the other. There was no perceptible difference in the diameter of the irises, nor in the contractility of them after having covered his eyes from the light. These observations were carefully made by writing single letters on shreds of paper, and laying wagers with the child that he could not read them when they were presented at certain distances and in certain directions.

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As from these circumstances it appeared that there was no defect in either eye, which is frequently the case with persons who squint, and hence that the disease was simply a depraved habit of moving his eyes, the disease seemed capable of a cure. A paper gnomon was made for this purpose, and fixed to a cap; and when this artificial nose was placed over his real nose, so as to project an inch between his eyes, the child, rather than turn his head so far to look at oblique objects, immediately began to view them with that eye which was next to them. But having the misfortune to lose his father soon after this method was begun to be followed, the child was neglected for six years, during which time the habit was confirmed in such a manner as seemed to leave little room to hope for a cure. The same physician, however, being again called, attempted a second time to remove the deformity by a similar contrivance. A gnomon of thin brass was made to stand over his nose, with a half circle of the same metal to go round his temples: these were covered with black silk, and by means of a buckle behind his head, and a cross piece over the crown of his head, this gnomon was worn without any inconvenience, and projected before his nose about two inches and a half. By the use of this machine he soon found it less inconvenient to view all oblique objects with the eye next to them than the eye opposite to them.

After this habit was weakened by a week's use of the gnomon, two bits of wood, about the size of a goose quill, were blackened all but a quarter of an inch at their summits; these were frequently presented to him to look at, one being held on one side the extremity of his black gnomon, and the other on the other side of it. As he viewed these, they were gradually brought forwards beyond the gnomon, and then one was concealed behind the other: by these means, in another week, he could bend both his eyes on the same object for half a minute together; and by continuing the use of the same machine, he was in a fair way of being cured when the paper was written.

Dr Darwin, who writes the history of the above case, adds, that all the other squinting people he had occasion to attend, had one eye much less perfect than the other: these patients, says he, are certainly cureable by covering the best eye many hours in a day; as by a more frequent use of the weak eye, it not only acquires a habit of turning to the objects which the patient wishes to see, but gains at the same time a more distinct vision; and the better eye at the same time seems to lose somewhat in both these respects, which also facilitates the cure.

Genus CXV. CONTRACTURA. 384

Contractions of the Limbs.

Contractura, *Sauv.* gen. 119. *Lin.* 299. *Sag.* 225.
Obstipitas, *Sauv.* gen. 11.

Caput

Apocenoses.

Caput obstipum, *Vog.* 513.
Digitium, *Vog.* 221.

The contraction of various muscles of the body is generally the consequence of some other disease, as the rheumatism, gout, scurvy, or palsy, especially that species of the latter which follows the *colica Pictonum*. It is exceedingly difficult of cure; though the warm medicinal waters are much recommended, and have sometimes done great service. Of late electricity has been found to perform surprising cures in this way.

385 ORDER IV. APOCENOSES.

Apocenoses, *Vog.* Class II. Ord. II.
Fluxus, *Sauv.* Class IX. *Sag.* Class V.
Morbi evacuatorii, *Lin.* Class IX.

386 GENUS CXVI. PROFUSIO.

FLUX of BLOOD.

Profusio, *Lin.* 239.
Hæmorrhagia, *Vog.* 81. *Boerh.* 218.

The disease commonly known by the name of *bloody flux*, is the putrid or contagious dysentery, a disease which has already been treated of. But independent of the discharge of blood which then takes place, hæmorrhagy may take place from the alimentary canal as well as from other parts of the system. In such instances, however, if we except the place from which the discharge occurs, the phenomena are very much the same as in menorrhagia, hæmoptysis, and other hæmorrhagies already treated of; while the disease is to be combated on the same principles and by the same remedies.

387 GENUS CXVII. EPHIDROSIS.

Excessive SWEATING.

Ephidrosis, *Sauv.* gen. 258. *Sag.* gen. 194.
Sudor, *Lin.* 208.
Hydropedesis, *Vog.* 121.

This is generally symptomatic; and occurs in almost all fevers, but especially in the latter stages of the hectic. Sometimes it is a primary disease arising merely from weakness; and then easily admits of a cure by the use of the cinchona, the cold bath, and other tonics.

388 GENUS CXVIII. EPIPHORA.

FLUX of the LACHRYMAL HUMOUR.

Epiphora, *Sauv.* gen. 259. *Lin.* 172. *Vog.* 99. *Sag.* 195.

This by Sauvages is described as an involuntary effusion of tears without any remarkable itching, heat, or pain. It follows long-continued ophthalmias; or it may be occasioned by immoderate study, or any thing that weakens the eyes: hence it comes on about the age of 50 years, when the eyesight naturally becomes weak. It in general grows worse in the winter-time, and is very hard to cure. Some authors recommend purgatives, and blisters on the nape of the neck, in order to draw off the abundant humours; but as the disease evidently proceeds from weakness, it would rather seem proper to pursue a contrary method. Sauvages recommends to the patients to abstain from study, wine, and salted meats; and also to avoid smoke or wind, and at night to foment the eyes with an infusion of four cloves in two ounces of proof-spirit.—Hungary water, rose water with sulphate of zinc dissolved in it, &c. have also been recommended.

Ptyalismus.

GENUS CXIX. PTYALISMUS. 389

SALIVATION.

Ptyalismus, *Sauv.* gen. 261. *Lin.* 176. *Vog.* 103. *Sag.* 197.

A salivation is often symptomatic, but rarely a primary disease. Dr Cullen is of opinion, that when the latter happens to be the case, it arises from laxity; and then is to be cured by astringents and tonics. In the Medical Transactions we have the following account of a salivation brought on by a foreign substance irritating one of the parotid glands.

In the month of April 1751, a young lady about the age of 16 years, of a delicate habit, but subject to no particular complaints, perceived the beginning of a disease which afterwards proved most obstinate and loathsome, viz. an incessant spitting. The quantity of this discharge was different at different times, varying from one pint to two pints and a half in 24 hours. As to its quality, it seemed to be no other than the ordinary secretion of the salival glands. By so large and constant an evacuation, her strength became extremely impaired, and the most efficacious medicines had proved useless She had taken large quantities of cinchona, both alone and combined with preparations of iron: and afterwards the fetid gums, opium, amber, alum, and the Neville-Holt water, had in succession been given her. In the mean time an exact regimen had been prescribed: she had been ordered to ride constantly; and to confine herself to a mucilaginous diet, such as veal, calves feet, &c. Likewise a gentle opening medicine had now and then been interposed. The disease still continued unaltered, she had afterwards tried the *tinctura saturnina*; and had, at the same time, been encouraged to chew cinchona, and to swallow the saliva. But all these attempts had been vain; and after she had taken some or other of the medicines above mentioned until the end of September 1753, namely, above two years, it appeared to her physician, Sir George Baker, unreasonable to expect relief in such a case from any internal medicines whatever.

He now conceived a suspicion, that some extraneous body having accidentally found its way into the *meatus auditorius*, might possibly be the cause of this extraordinary secretion, by keeping up a continued irritation in the parotid glands. With this view he examined her ears, and extracted from them a quantity of fetid wool. How, or when, it came thither, no account could be given.

To this substance he attributed the beginning of the salivation, notwithstanding that the disease did not immediately abate on the removal of the wool; as it appeared to be no improbable supposition that the discharge

Anorexiae. charge might be continued by the force of habit, though the original cause no longer remained.

It seemed, therefore, expedient to introduce some other habit, in the place of the increased secretion of saliva; which habit might afterwards be gradually left off. With this intention, he prevailed on the patient to chew perpetually a little dry bread, and to swallow it with her spittle. In a few weeks, it became necessary for her to chew the bread only at certain hours in the day; and thus, after two months, she became entirely free from a most disgustful and tedious disorder.

It is worthy of observation, that, at first, the swallowing of so much saliva frequently occasioned a nausea; and that then, for a few hours, she was obliged to spit it out as usual; and that during the greatest part of the time, when she chewed the bread, she had a stool or two every day more than common.

Genus CXX. ENURESIS.

An involuntary Flux of Urine.

Enuresis, *Sauv.* gen. 264. *Lin.* 195. *Vog.* 113. *Sag.* 200.

This is a distemper which frequently affects children, otherwise healthy, when asleep; and is extremely disagreeable. Often it is merely the effect of laziness, and may be driven off by proper correction; but sometimes it proceeds from an atony or weakness of the sphincter of the bladder. Many ridiculous cures have been prescribed for it, and among the rest fieldmice dried and powdered. Tonics are frequently of use; but sometimes the distemper proves obstinate, in spite of every thing we can use. In the London Medical Observations we find blisters much recommended in this disease when applied to the region of the os sacrum. A girl of 13 years of age had been subject to an enuresis for four years. She could retain her water but a very little while in the day-time, but it flowed continually in the night. She had taken Peruvian bark and elixir of vitriol in considerable quantities; also valerian and the volatile julep, without effect. She was severely threatened, as the physician suspected it might arise from a bad habit; but this producing no effect, a blister was applied to the os sacrum, which in 24 hours totally removed the disease. A man aged 32, having been seized with an incontinence of urine and palsy of the lower extremities in consequence of taking a quack medicine, was cured of the incontinence of urine in 24 hours by one blister, and of the palsy itself by another. A woman of 50 having been seized with an enuresis and paralytic affection of the right thigh and leg in consequence of a sprain, was cured of both by a single blister. Several other cases are mentioned, by which the power of blisters in removing this distemper seems to exceed that of every other medicine whatever.

Genus CXXI. GONORRHOEA.

Gonorrhœa, *Sauv.* gen. 208. *Lin.* 200. *Vog.* 118. *Sag.* 204.

The gonorrhœa is a flux of viscid matter of various colours, from the urethra in men and the vagina in women. It commonly proceeds from coition with a person infected with the venereal disease, and is one of the most common forms under which that disease shows itself.

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Description. The first symptoms of the disease in men are commonly a sensation at the end of the penis not unlike a flea-bite, together with a fulness of the lips of the urethra, and some degree of tension in the penis, the urinary canal feeling as if tightened, and the urine flowing in a small and unequal stream: a little whitish mucus is to be seen about the orifice of the urethra, and oozing from it when slightly pressed, especially if the pressure be made on the spot where the soreness is most felt. The discharge soon increases in quantity, and varies in its colour according to the degree of inflammation. The patient feels a sensation of heat and pain in evacuating his urine, particularly at certain spots of the urethra, and above all towards its orifice; and the involuntary erections to which he is subjected from the stimulus, particularly when warm in bed, occasion a distortion or curvature of the penis, attended with exquisite pain. When the inflammation is violent, the glans appears tumid and transparent, the tension extends through the whole of the penis, the perinæum is affected with swelling and redness, and even the loins, buttocks, and anus, sympathize and afford a very uneasy sensation. Sometimes the prepuce inflames about the end of the penis, and cannot be drawn back, occasioning what is called a *phymosis;* at other times, as in the *paraphymosis*, it remains in an inflamed state below the glans, so that it cannot be drawn forwards; and, if the stricture and inflammation be violent, may terminate in gangrene. Now and then, especially when there is a phymosis, we may perceive a hard chord extending along the back of the penis. This is an inflamed lymphatic, and may be considered as a prelude to a bubo. When, however, a bubo does appear, almost universally some ulceration is previously to be discovered about the præputium, or glans penis; which gives ground to presume that some other contagious matter besides that of gonorrhœa may have been applied to the urethra. For it is certain that matter capable of communicating the contagion of gonorrhœa to a female, is often copiously applied to the whole glans penis of a male for several days together, without giving either ulceration or bubo.

In mild cases, the seat of the disease is in the urethra, not far from its orifice; but it frequently happens that the virus insinuates itself much higher up, so as to affect Cowper's glands, the prostate, and parts very near to the neck of the bladder.

In the generality of cases, the inflammation goes on increasing for several days, commonly for a week or a fortnight; after which the symptoms begin to abate; and the running, when left to itself, gradually lessens in quantity, and becomes whiter and thicker, till at length it totally stops. The colour of the mucus, however, is by no means a certain guide in these cases: for in many patients it is of a yellowish, and sometimes of a greenish hue to the very last; but in general it becomes more consistent towards the close of the disease.

In women, the external parts of generation being fewer and more simple, the disease is less complicated than

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than in men. Sometimes the vagina only is affected; and when this happens, the symptoms are very trifling: but in general it comes on with an itching and sensation of heat as in the other sex; and is attended with inflammation of the nymphæ, inside of the *labia*, *clitoris*, *carunculæ myrtiformes*, the orifice and sometimes the whole of the *meatus urinarius*. Very often the deep-seated glands of the vagina are affected, and it is sometimes difficult to distinguish the discharge of a gonorrhœa from that of the fluor albus.

Causes, &c. Many ingenious arguments have of late been advanced to prove, that the gonorrhœa and the lues venerea are different affections, originating from two distinct species of virus; and this controversy still, perhaps, remains to be decided by future facts. Certain it is, that in 19 of 20 cases of gonorrhœa, no symptom whatever of siphylis appears; and that the disease readily admits of cure without having recourse to those remedies which are universally requisite for combating the contagion of siphylis. It is by no means wonderful, that in some cases both contagions, supposing them different, should be communicated at the same time. Nay, cases are by no means rare, where the contagion of itch, though essentially different from both, has been communicated with either. But as undeniable proof that the contagion in both cases is precisely the same, it has been alleged by some, that the matter of a chancre introduced into the urethra will generate a gonorrhœa, and that the discharge from a gonorrhœa will produce chancre, bubo, and every other symptom of siphylis. On the other hand, however, it is contended, that when experiments of this nature are conducted with the greatest accuracy, the matter of siphylis uniformly produces siphylis, and that of gonorrhœa, gonorrhœa only. Without pretending to decide on which of these experiments the greatest dependence is to be put, we may only observe, that while an almost inconceivably small portion of siphylitic matter applied to the glans penis, from connection with an infected female, infallibly produces siphylis if it be not speedily removed, the matter of gonorrhœa, in every instance of that disease, is applied to the whole surface of the glans penis for many days together without producing almost any bad effect whatever. From this, therefore, there is ground for inferring, either that it is not capable of being absorbed, or that if absorbed it is innocent.

But while there have been disputes with regard to the peculiar nature of the matter in gonorrhœa, there have also been controversies with respect to the source from whence it is derived. While some suppose it to be principally purulent matter arising from ulcerations, others assert that no such ulceration is ever produced in the urethra by gonorrhœa. They contend that the increased secretion in these cases is exactly similar to what happens in the catarrh. But the comparison will by no means hold good in every particular: in the latter the whole membrane of the nose is equally irritated; whereas in the gonorrhœa, only particular parts of the urethra seem to be affected. The disease, in the generality of cases, seldom extends more than an inch and a half along that canal, and in many is confined (at least in the beginning) to a small spot about an inch from the extremity of the glans. The discharge is produced from that part of the urethra where the pain is felt; and the patient, when he voids his urine, feels no smarting till it reaches the inflamed spot: but as the disorder increases, the inflammation affects a greater number of points, just in the same manner as chancres affect different parts of the glans. It might be supposed that dissection would at once clear up this matter, and put an end to the dispute; but this is far from being the case. Dr Simmons has seen several urethras opened in persons who had a gonorrhœa at the time of their death: in three of them the surface of the urethra, as in the cases related by Morgagni, appeared for some way down of a slight red colour, and in all of them was covered with mucus; but without any appearance of ulceration, except in two dissections at Paris, in which most of the gentlemen present were convinced that they saw evident marks of it: but Dr Simmons says that the appearances were to him not sufficiently satisfactory to enable him to decide with certainty on the subject. On the other hand, when we consider that the discharge in a gonorrhœa is sometimes tinged with blood, and that when this happens a little blood vessel is no doubt ruptured, we can have no reason to doubt that an ulceration may, and sometimes does, happen in these cases; especially as we often observe an excoriation near the orifice of the urethra. It is certain, that wherever there is considerable inflammation, there will be danger of ulceration. Besides, from a neglected or badly treated gonorrhœa, we often see fistulas *in perineo*, and other ulcers of the urethra, penetrating through its substance, and affording a passage to the urine. And there can be no doubt that slight ulcerations of this canal often occur, and are afterwards perfectly obliterated, in a similar manner to what happens in the papillæ of the tongue, the tonsils, &c. Such an obliteration will the more readily take place in a part like the urethra, defended with mucus, and not exposed to the air, which is known to have no little effect in hardening a cicatrix.

But whether ulcers take place or not, whether the virus of gonorrhœa be precisely of the same kind with that which gives siphylis, or of a different kind, there is reason from the phenomena of the disease to conclude, that the matter first acts by mixing with the mucus at the extremity of the urethra; and that from thence it is propagated upwards, particularly where the excretories of mucus are most numerous; and that on the parts to which it is applied, it operates as a peculiar irritating cause. The consequences of this irritation will be inflammation and an increased secretion of mucus; and so far the complaint will be local. In ninety-nine cases of an hundred, a local affection of this kind constitutes the whole of the disease; and of this inflammation, ulcerations within the urethra, strictures, and other local affections, may be the consequence. But whether a disease of the habit ever takes place, unless when the contagion of siphylis is communicated with that of gonorrhœa, still remains to be determined by future observations and experiments.

Nothing can be more variable than the period at which the disease makes its appearance after infection. Perhaps, at a medium, we may place it between the 4th and 14th day: but in some cases it happens within

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24 hours; and in others, not before the end of five or even six weeks: neither of these extremes, however, are common.

From what has been said of the manner in which the contagious matter in gonorrhœa acts, and of the influence it exerts on those parts with which it comes in contact, it follows, that the prevention of gonorrhœa must depend on the removal of the contagious matter, as soon as that can be done; and where this is either altogether neglected or not properly accomplished, that the cure must depend on counteracting the inflammation which this contagious matter excites, and the consequences which result from it.

The first of these intentions may be most certainly and most easily accomplished by careful lotion of all the parts to which the contagious matter has any chance of being applied. These parts, at least on the first application of the matter, are readily accessible: for even in men there is no reason to belive that it at first penetrates to any extent in the urethra. This washing of the parts should be performed as soon as possible; because then the matter is both most accessible and least involved with mucus: but although washing cannot be accomplished at an early period, it should not be neglected afterwards; for from the disease uniformly commencing, even when it does not appear till a considerable time after the application of the contagious matter, with a peculiar sense of titillation at the external parts, particularly in men at the extremity of the urethra, there is reason to believe that the contagious matter attached to the mucus may remain latent there for a very considerable time. For the purpose of washing, with a view to the prevention of this disease, recourse may be had to almost any watery fluid, provided it be not so stimulant as to produce bad effects from injuring the parts. Pure water, properly applied, is perhaps one of the best lotions; but there can be no doubt that its power in removing the contagious matter may be somewhat increased by such additions as render it a more powerful solvent of mucus. With this intention, one of the most powerful additions is the vegetable alkali, either in its mild or caustic state. In the latter state it is the most active, but in the former it is most safe; and the *carbonas potassæ* of the Edinburgh pharmacopœia, to the extent of half a dram, dissolved in six or eight ounces of water, is one of the best lotions that can be employed. The purpose of removing the contagion may often also be effectually answered from washing with water impregnated with soap; for there the alkali, though in a caustic state, is prevented from exerting any disagreeable effects, in consequence of its being combined with oily matters.

With the view of preventing gonorrhœa, some have advised, that the alkali either in its mild or caustic state, properly diluted with water, should be injected into the urethra: and there can be no doubt, that by this means the contagious matter, when it has entered the urethra, may be removed. A removal may also be effected by the injection of a weak solution of corrosive sublimate, which seems to act not by dissolving the mucus but by producing an augmented secretion. But at a very early period of the disease, injections are probably unnecessary; and if it has made any considerable progress, they are dangerous: for from the augmented sensibility of the part, even very gentle ones are apt to excite a high degree of inflammation.

There are practitioners who, supposing that the body possesses powers to expel the virus, and that the disease has a certain period to run through its several stages of progress, acmè, and decline, are for leaving the cure to nature; or at least content themselves with assisting her by an antiphlogistic regimen, gentle evacuations, and the like.

That in many cases the disorder admits of a natural cure, there can be no doubt; the increased secretion of mucus carrying off the virus faster than it is formed, till at length the infection is wholly removed: But it is equally certain, that in every case, by the application of suitable remedies to the inflamed part, we may shorten the duration of the complaint. and abridge the sufferings of the patient, with the same certainty and safety as we are enabled to remove the effects of an ophthalmia or any other local inflammation, by proper topical applications. General remedies, such as occasional blood-letting, a cooling diet, the liberal use of diluting liquors, and mild purges, are by all allowed to be useful, and even necessary. Astruc was of opinion that in these cases blood-letting ought to be repeated five or six times; and there are still many practitioners who depend much on repeated evacuations of this sort for a removal of the inflammation. But there is, perhaps, not one case in ten in which it is at all requisite; and this small number of cases will consist only of the strong and plethoric: in such, when the chordee is frequent and painful, and the pulse hard and full, the loss of from eight to twelve ounces of blood will be beneficial, but it will be seldom necessary to repeat the operation. The inflammation in these cases is kept up by the local stimulus of the virus and the urine; and all that we can expect from venesection is to moderate the pain and the frequency of erection. In persons of a delicate habit, and of an irritable fibre, the evacuation will do no good; but if repeated will certainly be liable to do harm, by increasing irritability, and of course rendering the patient more susceptible of stimulus.

The utility, and even the necessity, of a cooling regimen, are sufficiently obvious; wine and spirituous liquors, spiceries, a fish-diet, much animal-food, and salted and high-seasoned dishes of every sort, will constantly add to the complaint. The patient should eat meat only once a-day, and that sparingly. He should abstain from hot suppers. Milk, mild vegetables, and fruit, should constitute the principal part of his diet while the inflammatory symptoms continue. Every thing that tends to excite the venereal imagination should be studiously avoided; for whatever promotes erections of the penis will increase the inflammation, and of course add fuel to the disease. For the same reasons much walking or riding on horseback will be hurtful, from the irritation kept up in the perinæum by such means. Violent exercise of any kind, or any thing that is liable to increase the heat and the momentum of the blood, will of course be improper.

The drinking freely of mild, cooling, mucilaginous liquors, such as linseed tea, orgeat, whey, milk and water, almond emulsion, and the like, will be extremely useful, by diluting the urine, and preventing its salts from stimulating the urethra. When the heat and pain in making water are very considerable, mucilaginous substances

Apocenoses.

substances are found to have the best effect, particularly the gum tragacanth. It is a common practice to give equal quantities of this gum or gum arabic and nitre, and to dissolve nitre in the patient's drink, with a view to lessen the inflammation. But in these cases nitre is always improper: it is known to be a powerful diuretic, its chief action being upon the urinary passages; so that the stimulus it occasions will only serve to increase the evil it is intended to alleviate. Supertartrite of potass, on account of its diuretic quality, will be equally improper. Our view here is not to promote a preternatural flow of urine; for the virus, being insoluble in water, cannot easily be washed away by such means; but our object ought to be, to render the urine that is secreted as mild and as little stimulating as possible.

Mild purges, which constitute another material part of the general remedies, are no doubt extremely useful when exhibited with prudence; but it is well known that the abuse of purgative medicines in this disease has been productive of numerous evils. Formerly it was a pretty general practice to give a large dose of calomel at bed-time, three or four times a-week; and to work it off the next morning with a strong dose of the *pilulæ cocciæ*, or some other drastic purge. This method was persevered in for several weeks: in consequence of which the patient often found himself troubled with an obstinate gleet, and perhaps his constitution materially injured; the effect of such a method being (especially in irritable habits) to weaken the stomach and bowels, and lay the foundation of hypochondriacal complaints. Violent purging likewise often occasions strangury, and other troublesome symptoms.

The cathartics employed in these cases should be gentle; such as Rochelle salt, manna, tartarised alkali, and the like. They should be given only in a dose sufficient to procure two or three stools, and be repeated only every two or three days. The daily use of the purgative electuaries that are still given by some practitioners, serves only to keep up a continual irritation on the bladder, and of course to prolong the inflammation.

The topical remedies that are used consist chiefly of different sorts of injections, the ingredients of which are extremely various; but their modes of operation may in general be referred to their mucilaginous and sedative, or to their detergent, stimulating, and astringent qualities. In the hands of skilful practitioners, great advantages may doubtless be derived from the use of these remedies; but, on the other hand, the improper and unseasonable administration of them may prove a source of irreparable mischief to the patient.

We know that mucilaginous and oily injections will tend to allay the local inflammation; and that a sedative injection, such as a solution of opium, will lessen the irritability of the parts, and of course produce a similar effect; the utility of such applications is therefore sufficiently obvious.

A detergent injection, or one that will act upon the mucus of the urethra, increase the discharge of it, wash it away, and with it the venereal virus that is blended with it, can only be used as a prophylactic before the symptoms of infection have made their appearance. But great circumspection is necessary in the use of this kind of injection. If it be too weak, it can be of no efficacy; and if it be too strong, it may prove dangerous to the patient. A suppression of urine has been brought on by the improper use of an injection of this kind. When the symptoms of inflammation have once made their appearance, the stimulus of such an injection must be extremely hazardous. Excoriation of the urethra has but too often been produced by remedies of this sort in the hands of adventurous and unskilful practitioners.

Gonorrhœa.

While the inflammation of the urethra continues, every thing that stimulates it must be hurtful. If the injection excites a painful sensation in the urethra, as is but too often the case, it will be liable to produce swelled testicles, difficulty in making water, excoriation, and other effects of increased inflammation: if, by its astringency, the running be checked before the virus that excited the discharge be properly subdued, the patient will be exposed to fresh dangers; and perhaps to a variety of local complaints, such as obstructions in the urethra, and abscesses *in perinæo*, which are well known to be sometimes owing to applications of this sort improperly managed.

When the inflammation has subsided, gently stimulating and astringent injections may be used with safety, and with considerable advantage: for as the inflammation is at first excited by the stimulus of the venereal virus, so when the former begins to lessen, we may be assured that the activity of the latter has abated in proportion; and, in general, when the inflammatory symptoms are entirely removed, it will be found, that the mucus is no longer of an infectious nature, but is merely the effect of an increased secretion and of relaxation. Mild astringents will therefore serve to brace and strengthen the vessels secreting mucus, and in this way will lessen the discharge, and greatly promote the cure. It is certain, that in the greater number of cases, a gonorrhœa, which if treated by internal remedies alone, would continue for five or six weeks, or longer, may, when judiciously treated with injections, be cured in a fortnight, and very often in less time. The great aim, therefore, of the practitioner ought to be at first to make use of such injections only as will tend to lubricate the surface of the urethra, and to counteract and destroy the stimulus of the virus: as the inflammation abates, he may add some gently astringent preparation to a mucilaginous and sedative injection; taking care that its astringency be suited to the state of the disease, and to the irritability of the patient. Amongst a great variety of substances, mercury in different forms is one of those that is the most frequently employed in injections. All these mercurial injections have more or less of astringency; and, according to Dr Simmons, it is solely to this property that we are to ascribe their effects; for the idea of their correcting the venereal virus was originally introduced, and has, he thinks, been continued, upon mistaken principles.

Calomel, mixed with the mucus discharged in a gonorrhœa, has no more power in destroying the infectious properties of that mucus than ceruse or any other preparation would have. A diluted solution of sublimate injected into the urethra, will, like a solution of verdigrise, or blue vitriol, or any other styptic, constringe the mouths of the lacunæ; but this is all that it will do, for it will never lessen the infectious nature of the virus. This same thing may be observed of crude

Gonorrhoea. crude mercury extinguished by means of mucilage, or of mercurial ointment, blended with the yolk of an egg, and which, when thrown up into the urethra, will act nearly in the same manner as balsam of copaiva, or any other stimulating injection. The stimulus of mercury, however, has often been found of considerable efficacy; and in women, when the vagina only was affected, after washing the parts well, the cure has been accomplished by rubbing them repeatedly with mercurial ointment.

As the gonorrhœa is only a local affection, it may be inferred, that the internal use of mercury is unnecessary towards the cure. Very often indeed this complaint may be removed without having recourse to mercurials. Sometimes patients have been met with whose general health has been greatly impaired by a long continued use of mercury in such cases, while the original disease, the gonorrhœa, was rendered much worse by it. In some it has degenerated into a gleet, that was cured with extreme difficulty; in others it has brought on a variety of distressing symptoms. In cases of gonorrhœas, therefore, whenever mercury is administered, it ought to be, not with a view to expedite the cure, but merely to obviate the dangers of siphylis. When the infection is apparently slight, and the inflammation and the symptoms trifling, we may proceed without the assistance of mercury, especially if the patient be of a weak, relaxed, and irritable habit, likely to be injured by mercurial medicines. On the other hand, when the discharge is violent, the inflammation considerable, or the seat of the disease high up in the urethra, it is perhaps the most prudent plan to give mercurials in small doses, and in such forms as seem the best adapted to the constitution of the patient.

The *pilulæ hydrargyri*, as prepared according to the receipts inserted in the last edition either of the London or Edinburgh Pharmacopœias, in both of which the mercury is rendered active merely by triture, may perhaps be considered as one of the mildest and most efficacious forms under which mercury can be exhibited by the mouth. Its efficacy will depend on its not irritating the bowels, and thus passing off by stool; care must likewise be taken to prevent its affecting the mouth. Of the chemical preparations of mercury, the mildest and least irritating is calomel. It may be given from gr. iß. to gr. iii. at bed-time, occasionally interposing a mild purgative to prevent it from salivating; but in general the mercurial pill just mentioned is to be preferred.

When there is no chancre or bubo, no appearance in short of siphylitic infection, it would be improper to administer corrosive sublimate, the mercurius calcinatus, or any other of the more acrid preparations of mercury.

After a gonorrhœa proceeding from venereal causes has been removed, another kind of running without pain, called the *gonorrhœa mucosa*, or *gleet*, sometimes remains. Sometimes it arises from a constriction and excoriation of the urethra, and frequently it is the effect of an enlargement and diseased state of the prostate. In each of these cases, as the gleet is the effect of irritation, the cure will depend on the removal of the local disease that occasions it. But there is another species of gleet that seems to depend chiefly on relaxation. It is in general free from infection, and is most common in those who have had long and frequent gonorrhœas. It is likewise often the effect of a debilitated habit, from severe purging, or a long continued use of mercurials. A discharge of this kind is more frequent in women than in men; or, at least, the fluor albus, after a gonorrhœa, will often be mistaken for a gleet.

When there is no reason to suspect remaining contagion, astringent injections will be of the greatest service. It will be necessary, at the same time, to attend to the health of the patient, by employing cinchona, chalybeate waters, cold bathing, and such other remedies as will tend to strengthen the system: and indeed by the use of these, particularly by the cinchona, such runnings are often successfully combated in those who from apprehension of dangerous consequences cannot be prevailed upon to employ injections. When there is no tendency to inflammation, the balsam of copaiva may be prescribed with advantage in large doses. Dr Simmons says he once saw a complaint of this sort removed by applying a blister to the perinæum, after it had resisted a variety of other remedies. In the Medical Observations also we have an account of a gleet and incontinence of urine removed at once by a blister to the os sacrum. In general, however, the other methods above mentioned will be sufficient to remove it, though sometimes it will continue for a long time in spite of all our endeavours to check it.—Other kinds of gonorrhœa, in which the semen itself is ejected, especially during sleep, may be cured by tonics and a mild cooling regimen.

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Genus CXXII. OBSTIPATIO. 393

Costiveness.

Obstipatio, *Lin.* 166. *Vog.* 128. *Sag.* 221.

Obstipatio. Costiveness is sometimes occasioned by debility in dyspeptic persons, sometimes it is the effect of rigidity, and sometimes it is symptomatic of the colic. It may proceed from an affection of the liver; drinking rough red wines, or other astringent liquors; too much exercise, especially on horseback: it may likewise proceed from a long use of cold insipid food, which does not sufficiently stimulate the intestines. Sometimes it is owing to the bile not descending to the intestines, as in the jaundice: and at other times it proceeds from diseases of the intestines themselves, as a palsy, spasms, tumors, &c.

Excessive costiveness is apt to occasion pains of the head, vomiting, colics, and other complaints of the bowels. It is peculiarly hurtful to hypochondriac and hysteric persons, as it generates wind and other distressing symptoms.

Persons who are generally costive should live upon a moistening and laxative diet; as roasted or boiled apples, pears, stewed prunes, raisins, gruels, with currants, butter, honey, sugar, and such like. Broths with spinage, leeks, and other soft pot-herbs, are likewise proper. Rye-bread, or that which is made of a mixture of wheat and rye together, ought to be eaten. No person troubled with costiveness should eat white bread alone, especially that which is made of fine flour.

Epischeses. flour. The best bread for keeping the belly soluble is what in some parts of England they call *meslin*. It is made of a mixture of wheat and rye, and is very agreeable to those who are accustomed to it.

Costiveness is increased by keeping the body too warm, and by every thing that promotes the perspiration; as wearing flannel, lying too long in bed, &c. Intense thought, and a sedentary life, are likewise hurtful. All the secretions and excretions are promoted by moderate exercise without doors, and by a gay, cheerful, sprightly temper of mind.

The drink should be of an opening quality. All ardent spirits, austere and astringent wines, as port, claret, &c. ought to be avoided. Malt liquor that is fine and of a moderate strength is very proper. Butter-milk, whey, and other watery liquors, are likewise proper, and may be drank in turns, as the patient's inclination directs.

Those who are troubled with costiveness ought, if possible, to remedy it by diet, as the constant use of medicines for that purpose is attended with many inconveniences, and often with bad consequences. In time the custom becomes necessary, and generally ends in a total relaxation of the bowels, indigestion, loss of appetite, wasting of the strength, and death.

The learned Dr Arbuthnot advises those who are troubled with costiveness to use animal oils, as fresh-butter, cream, marrow, fat broths, &c. He likewise recommends the expressed oils of mild vegetables, as olives, almonds, pistaches, and the fruits themselves; all oily and mild fruits, as figs; decoctions of mealy vegetables; these lubricate the intestines; some saponaceous substances which stimulate gently, as honey, hydromel, or boiled honey and water, unrefined sugar, &c. are useful.

The doctor observes, that such lenitive substances are proper for persons of dry atrabiliarian constitutions, who are subject to astriction of the belly and the piles, and will operate when stronger medicinal substances are sometimes ineffectual; but that such lenitive diet hurts those whose bowels are weak and lax. He likewise observes, that all watery substances are lenitive; and that even common water, whey, sour-milk, and butter-milk, have that effect:—That new milk, especially asses milk, stimulates still more when it sours on the stomach; and that whey, turned sour, will purge strongly:—That most part of fruits are likewise laxative; and that some of them, as grapes, will throw such as take them immoderately, into a cholera morbus, or incurable diarrhœa.

When the body cannot be kept open without medicine, gentle doses of rhubarb may be taken twice or thrice a-week. This is not near so injurious to the stomach as aloes, jalap, or the other drastic purgatives so much in use. Infusions of senna and manna may likewise be taken, or half an ounce of tartarised alkali dissolved in water gruel. About the size of a nutmeg of lenitive electuary taken twice or thrice a-day, generally answers the purpose very well.

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Genus CXXIII. ISCHURIA.

Suppression of *Urine*.

Ischuria, *Sauv.* gen. 293. *Lin.* 167. *Vog.* 129. *Sag.* 212. *Home's* Clinical Experiments, sect. xv.

Ischuria. This disease is distinguished into various species, according as the seat of it is in the kidneys, the ureters, the bladder, or the urethra; and hence these species are named *renalis*, *ureterica*, *vesicalis*, and *urethralis*.

1. *Ischuria renalis*, or a suppression of urine from an affection of the kidneys, happens but rarely; however, Dr Home in his Clinical Experiments describes such a case. In the end of December 1774, a man of a full habit, aged 35, was seized with shivering, coldness, and severe cough. Three days after, his urine appeared high-coloured, was passed with pain, and in small quantity. About the 8th of January 1775, he was attacked with violent pains in the small of his back, over the whole abdomen, and in the ankles, with pain in the region of the liver when pressed. A general swelling was afterwards observed all over the body, but chiefly in the ankles and abdomen, which last was tense and hard. These were attended with vomiting, bad appetite, and considerable thirst. When he entered the clinical ward (January 21st), the cough, sickness, and vomiting, had gone off, but the suppression of urine remained. The little which he made was passed with his stools, so that Dr Home saw it but once; and then it was pale, and had a white powder at bottom. The pains and swellings which retained the impression of the finger, continued; he had a headach, and a very slow pulse, beating only 48 strokes in a minute. He had taken a great many diuretic medicines before his admission. The day after his reception, he was seized with a spontaneous diarrhœa, which continued during the remainder of his life. Crystals of tartar were exhibited in doses of half an ounce each morning; at bed-time he took 20 drops of tincture of opium with a scruple of nitre, and continued this course for eight days without any increase of urine. The stronger and heating diuretics were then tried, as an infusion of juniper berries and pills of garlic; but they were attended with no manifest advantage. Whenever the pulse became so strong that he could bear bleeding, eight ounces of blood were taken away, which was sizy. This was thrice repeated; he appeared easier after each bleeding, his pulse bore it well, and the swellings and other symptoms abated. The heating diuretics, in this state, were given up, and a mixture of vinegar and nitre was substituted in their place, in each dose of which, taken every two hours, there was a scruple of nitre. Fomentations were applied to the region of the kidneys, and camphorated oil was afterwards rubbed on the part. He was ordered the semicupium, which, from a deficiency of water in the hospital at that time, he got only once; and which then seemed to have a good effect, as he passed a gill of urine when he was in it. Notwithstanding this, however, the disease continually gained ground; he became comatose, delirious, and died ten days after his admission. On dissection, the kidneys were found of an irregular form; some watery vesicles appeared on their surface, containing black gritty particles like fine sand; and the lower part of the right kidney was considerably inflamed. The pylorus, part of the duodenum, and a considerable part of the small intestines, were much inflamed. In the abdomen were found about five pounds of fluid, and in the cavities of the thorax about half a pound. The

Epilepses. The lungs were a little inflamed, and full of small tubercles on their surface and in their substance: the heart was large, and a polypus in each ventricle. About six ounces of fluid were found in the pericardium: in the brain nothing preternatural appeared, except about an ounce of water in each ventricle.

Dr Home seems to have been at a loss for the remote cause of this suppression of urine, which manifestly had its immediate origin from the kidneys having lost the power of performing their functions. He thinks the inflammation which appeared in the right kidney was scarce sufficient to have occasioned the distemper, as the other would have supplied its place: for which reason also he thinks that the ischuria was owing to a general affection of the system; and that it was of an arthritic nature, the patient having been troubled with complaints of that kind for a long time before.

96 2. The *ischuria ureterica* is also a rare disease, unless the obstruction proceeds from a stone or clot of blood stopping up the passage. Gravel or stones, indeed, are very frequently formed in the kidneys: and, by falling into the ureters, occasion an ischuria, with violent pain, and symptoms more or less urgent in proportion to the size and shape of the stones. Sometimes it is attended with coldness of the extremities, nausea, vomiting, and spastic constriction of the præcordia, a difficulty of making water, constipation of the belly, difficulty of breathing, stupor of the thigh, retraction of the testicle, inquietude, loss of strength, syncope, and convulsion fits. When the violent pain has continued for several days and nights without intermission, and has brought the patient exceeding low, and the suppression of urine is complete, with coldness of the extremities and convulsions of the tendons, death is at hand. Nor is it a good sign when the stone continues long in the ureter; for then the appetite decays, a nausea and retching to vomit supervene, and the patient is consumed with a hectic heat. Sometimes the pain is attended with an inflammation of the stomach and intestines; and sometimes the disease ends in a dropsy of the breast, or lethargy, which soon carry off the patient.

The indications of cure are, to exclude the stone as easily as possible, and prevent the breeding of others. If the patient be of a sanguineous temperament, Sydenham recommends to take away ten ounces of blood from the affected side; and then to give the patient a gallon of posset-drink in which two ounces of marshmallow roots have been boiled, injecting at the same time an emollient glyster. After the posset drink has been vomited up, and the clyster returned, give a pretty large dose of an opiate. But if the patient be old or weak, or subject to nervous affections, bleeding may be omitted, especially if his urine at the beginning of the fit be coffee-coloured, and mixed with gravel; but as to the other things, the cure is the same. Huxham highly recommends an emollient bath prepared of a decoction of marshmallow root, lintseed, fœnugreek seed, and flowers of chamomile, to which may be added a few white poppy seeds. By the use of this bath he says he has seen the most cruel fit of the gravel suddenly ended, when neither copious bleeding nor opiates had the least effect. Mild diuretics are also of service. Hoffman recommends dulcified spirit of nitre as proper to relax the spastic stricture. It is to be taken with suitable distilled waters and syrup of poppies; or in broth, with a few spoonfuls of oil of sweet almonds. Turpentine glysters are also accounted very serviceable; and may be prepared with ten ounces of a decoction of chamomile, with half an ounce of turpentine dissolved in the yolk of an egg, and about as much honey. The *sal diureticus*, or *acetis potassæ*, is much esteemed by some, when taken along with an opiate. But when the stone is too big to pass, Arbuthnot recommends a cool and diluent diet to hinder the further growth of it. Whey, infusion of lintseed, decoction of marshmallows, and gently resolving diuretics, are also proper. To put a stop to the vomiting, the compound tincture of benzoin, formerly named *balsamum traumaticum*, has sometimes been used with success, when almost every other means have failed.

Ischuria.

3. The *ischuria vesicalis* may arise from a stone in the bladder; and this indeed is the most common cause of it: but there are certain cases, in which, though the usual quantity of urine, or perhaps more, be passed, the patient dies from the retention of a still greater quantity in the bladder. Of this Dr Hume gives the following instances. A man of 58 years of age, of a strong spare habit, and never subject to the gravel, had, during the winter of 1777, a cough with expectoration, which went off in the beginning of 1778. About the 17th of February 1778 he felt some difficulty in passing his urine, and much pain about the region of the bladder. He continued in this way for ten days, after which he became easier on application of some medicines. The abdomen then swelled, and he had pains in his loins and thighs. On the 3d of March he was admitted into the clinical ward; his abdomen was then swelled and tense; and an evident fluctuation was felt, which some that touched him thought was sonorous and produced by wind. A tumor was discovered between the navel and spine of the os ilium on the left side, which gave him much pain, especially when pressed. This tumor became more easily felt after the swelling of the abdomen decreased, seemed round, and very near as large as the head of a child. It appeared very much on the left side, even when the patient lay on the right, and it then became dependent. He passed urine frequently, and rather more than in health, as it was computed at four pints a-day. It was always clear, and of a light colour. His body had a strong disagreeable smell; his skin was dry, belly bound, and his appetite entirely gone, so that he had hardly taken any food for 12 days. His legs swelled slightly for some days in the evening. His pulse was generally regular, sometimes slower than natural, and sometimes a little quicker; being once felt at 64, and another time at 92. He was often seized, especially after eating or drinking, with hiccough; which increased and lasted till his death. On the 20th day of his disease, after some doses of squills, the general swelling of his abdomen fell, became much softer, and more distinctly discovered the swelling of the left side. The next day a vomiting came on; he became delirious, and died the day following. The body being opened, it appeared that the tumor which was so distinctly felt on the left side of the abdomen, was owing to a distention of the bladder with urine. Its fundus reached to about the division of the aorta into the

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Epischeses. the iliacs; it entirely filled the pelvis, and contained between five and six pounds of urine of a pale colour. On examining the external surface, its neck, and the beginning of the urethra, were found to be surrounded with a scirrhosity, which impeded the evacuation of the urine. The bladder itself was much thickened, but not more in one part than another. The ureters entered naturally; but were much thickened in their upper half near the kidney. The kidneys were somewhat enlarged; particularly the left, which had several watery vesicles on its external surface. These organs were not in their usual situation; but lay close on each side of the spine, and very near the aorta: so that the renal vessels were very short. What was very singular, the lower end of each arose over the spine, and they were united together by their membranes, the aorta passing beneath the union. The bladder had pressed considerably on this part; and the peritoneum covering them was considerably thicker than natural. The lungs adhered every where to the pleura, and in some places very firmly: they were of a loose texture and black colour; and the veins of the lower extremities were turgid with blood. It does not appear that this patient got any medicines farther than a few dried squills, which diminished the swellings and brought off much wind. He also got a mixture of musk, and afterwards of opium, for his hiccough; but without success. His disease was mistaken for an ascites; and the catheter was not tried: but in another case the use of this instrument was apparently of more service than any internal medicines. This last patient was about 90 years of age, and laboured under symptoms very similar to those already mentioned. When admitted into the clinical ward, he had the hypogastric region swelled, and difficulty of passing his water; but without pain, vomiting, or hiccough. He had lost all appetite; was thirsty, and costive. His pulse was 110, and weak. In the evening about three English pints of pale clear urine were drawn off by means of the catheter: the next day all the symptoms were gone off or abated. After this he continued to pass some urine, sometimes voluntarily, sometimes involuntarily and insensibly: but so much always remained behind, that his bladder was constantly full, unless when the urine was drawn off, which was done twice every day. The urine was sometimes pale, sometimes of a deep red colour; and once there was some blood mixed with it, which perhaps might have been occasioned by the catheter. About the sixth day the urine was very putrid, with much purulent like matter at the bottom, and was passed with more pain. About the 11th, the putrid smell went off. The next day all the urine passed insensibly except what was drawn off; and an hiccough, though not very severe, had come on. In this way he continued without fever, though frequently troubled with the hiccough, especially during those nights in which the urine had not been drawn off. A month after admission, the bladder, with the assistance of the catheter, was almost entirely, though insensibly evacuated, and the hiccough had left him; he had no other complaint but that of voiding his urine insensibly, the natural effect of a scirrhous bladder, and which was probably incurable. With this patient the hot bath and mercurials were tried, in order to soften the scirrhosity of the bladder, but without effect. Ischur.

4. The *ischuria urethralis* arises from some tumor obstructing the passage of the urethra, and thus hindering the flow of the urine. It is no uncommon distemper, and often follows a gonorrhœa. Dr Home gives us an example of this also.—The patient was a man of 60 years of age, who had laboured under a gonorrhœa six months before, and which was stopped by some medicines in two or three days. He felt, soon afterwards, a difficulty in passing his urine, which gradually increased. About 10 days before his admission into the clinical ward, it was attended with pains in the glans, and *ardor urinæ;* he had passed only about eight ounces the day before his admission, and that with very great difficulty; and the hypogastric region was swelled and pained. On introducing the catheter, three pounds of urine were drawn off, by which the pain and swelling were removed. The instrument required force to make it pass the neck of the bladder, and blood followed the operation: and the finger, introduced into the anus, felt a hard tumor about its neck. He was treated with mercurial pills and ointment, by which the swelling about the neck of the bladder soon began to decrease; but at the same time a swelling of the right testicle appeared. He was vomited with four grains of turbith-mineral, the *subsulphas hydrargyri flavus* of the present pharmacopœia, which operated gently; and here Dr Home observes, that though these vomits are little used, from a mistaken notion of their severity, he never saw them operate with more violence than other vomits, or than he could have wished. The swelling diminished in consequence of the emetic and some external applications; and the cure was completed by bleeding and a decoction of mezereon root. 398

Genus CXXIV. DYSURIA. 399

Difficulty of discharging urine.

Dysuria, *Sauv.* gen. 265. *Lin.* 57. *Vog.* 164. *Sag.* 213.
Stranguria *auctorum.*

A difficulty of making water may arise from many different causes; as from some acrid matter in the blood, cantharides, for instance; and hence a strangury very often succeeds the application of blisters. In many cases it arises from a compression of some of the neighbouring parts; of the uterus, for instance, in a state of pregnancy. Or it may arise from a spasmodic affection of the bladder, or rather its sphincter; or from an inflammation of these parts, or others near them. Hence the disease is distinguished into so many species, the cure of which is to be attempted by remedies indicated by their different causes.

But the most common, as well as the most dangerous species is that arising from a calculous concretion, or

Stone in the Bladder.

Dysuria calculosa, *Sauv.* sp. 12. 400

The signs of a stone in the bladder are, pain, especially about the sphincter; and bloody urine, in consequence

Epileses. quence of riding or being jolted in a carriage; a sense of weight in the *perinæum*; an itchiness of the *glans penis;* slimy sediment in the urine; and frequent stoppages in making water; a *tenesmus* also comes on while the urine is discharged: but the most certain sign is, when the stone is felt by the finger introduced into the anus, or by sounding.

Causes, &c. It is not easy to say what the particular causes are which occasion the apparently earthy particles of the fluids to run together, and form those calculous concretions which are found in different parts of the body, and especially in the organs for secreting and discharging the urine.

The gout and stone are generally supposed to have some affinity, because gouty people are for the most part afflicted with the gravel. But perhaps this is in part owing to their long confinement, and to lying on the back, which people who labour under the gout are often obliged to submit to; since the want of exercise, and this posture, will naturally favour the stagnation of gross matters in the kidneys: besides, there are many instances of people severely afflicted with the stone for the greatest part of a long life, who have never had the least attack of the gout.

There is, however, good reason for believing, that some farther connection takes place between the two diseases; and when treating of the gout we have already given some account of the opinion of an ingenious anonymous author, who has endeavoured to prove, that both the one and the other depend on a peculiar acid, the concreting, lithic, or uric acid, which is always present in blood; and which may be precipitated from thence by various causes, such as the introduction of other acids, or the like. When thus precipitated, he supposes it to produce the whole phenomena of both diseases. The objections we formerly stated to his theory of gout, do not equally militate against that of calculus; and it is at least certain, from the best chemical analysis, that what are commonly called *urinary calculi*, and have been considered as entirely an earthy matter, consist principally of acid in a solid state united only with a small proportion of earth or mucus. We may, therefore, whether this hypothesis be altogether well founded or not, justly view lithiasis as depending, in a great measure, on the separation of an acid from the blood.

Whatever may be the particular cause of the disposition to *lithiasis*, the kidneys appear to be the most likely places for particles to concrete or run together, because of the great quantity of blood which passes through the renal arteries, and which comes immediately from the heart, fraught with various newly received matters, that have not undergone much of the action of the vessels, and therefore cannot as yet be supposed to be thoroughly assimilated.

Anatomists who have carefully examined the kidneys in the human subject, particularly M. Bertin, inform us, that there are two sets of *tubuli uriniferi;* the one continued directly from the extremities of the renal artery, and the other springing from that vesicular texture which is conspicuous in the kidneys.

It is in this vesicular part of the kidney that we presume the particles of the concreting matter first stagnate and coalesce: for it is hardly to be supposed, that such solid matters could be allowed to stop in the extremities of the renal arteries, since the blood, and the urine separated from it, must flow through these vessels with great degrees of force and velocity; but in the intermediate vesiculæ the particles may lie, and there attracting each other, soon come to acquire sensible degrees of magnitude, and thus become sand or gravel. As long as this sand or gravel formed in the vesicular part of the kidney lies quiet, there will be no pain or uneasiness, until the concretions become large enough to press either on the adjoining *tubuli*, or on the blood-vessels; then a sense of weight, and a kind of obtuse pain in the loins, will be left. But when the small pieces of concreting matter shall be dislodged and washed off by the force of the circulating fluids, or loosened by some spasmodic action of the moving fibres in these parts, they will in their passage create pain, raise different degrees of inflammation, or perhaps lacerate some blood-vessels, and cause bloody urine. When these little concretions happen to be detained in the pelvis of the kidney, or any other place where a flow of urine continually passes, they soon increase in size, and become calculi, from the constant accession of particles, which are attracted by the original bit of sand, which thus becomes the nucleus of a stone.

Dysuria.

It is an opinion which Hippocrates first advanced, and which has been almost universally adopted by his followers, and has remained till lately uncontroverted, that the stone and gravel are generated by the use of hard water. From the quality, which the waters of certain springs possess, of depositing a large earthy sediment, either in the aqueducts through which they are conveyed, or in the vessels in which they are boiled or preserved, it was conjectured, that in passing through the kidneys, and especially whilst retained in the bladder, they would let fall their grosser particles, which by the continued apposition of fresh matter, connected by the animal gluten, and compacted by the muscular action of that organ, would in time form a calculus sufficiently large to produce a train of the most excruciating symptoms. And this reasoning *à priori* has been supposed to be confirmed by facts and experience; for not to mention the authority of Hippocrates, Dr Lister has observed, that the inhabitants of Paris are peculiarly subject to the stone in the bladder. Nicholas de Blegny has related the history of one who was dissected at Paris, in whom the pylorus, a great part of the duodenum, and the stomach itself, were found incrustated with a stony matter, to the thickness of a finger's breadth. And it is well known, that the water of the river Seine, with which that city is supplied, is so impregnated with calcareous matter, as to incrustate, and in a short time to choke up, the pipes through which it runs. But on the other hand it is objected, that the human calculus is of animal origin, and by chemical analysis appears to bear very little analogy to the stony concretions of water: and though it be allowed, that more persons are cut for the stone in the hospitals at Paris than in most other places; yet upon inquiry it is found, that many of those patients come from different provinces, and from towns and villages far distant from the Seine.

Dr Percival conjectures, that though this disease may chiefly depend upon a peculiar disposition to concrete in

Epischeses. in the animal fluids, which in many instances is hereditary, and in no instance can with certainty be imputed to any particular cause; yet hard water is at least negatively favourable to this diathesis, by having no tendency to diminish it. The urine of the most healthy person is generally loaded with an apparently terreous matter, capable in favourable circumstances of forming a calculus; as is evident from the thick crust which it deposits on the sides of the vessels in which it is contained. And it seems as if nature intended by this excretion to discharge all the superfluous salts of the blood, together with those earthy particles, which are either derived from our aliment, and fine enough to pass through the lacteals, though insuperable by the powers of circulation, or which arise from the abrasion of the solids, or from the dissolution of the red globular part of our fluids. Now water, whether used as nature presents us with it, or mixed with wine, or taken under the form of beer or ale, is the great diluter, vehicle, and menstruum, both of our food, and of the saline, earthy, and excrementitious parts of the animal juices. And it is more or less adapted to the performance of these offices, in proportion to its degree of purity. For it must appear evident to the most ordinary understanding, that a menstruum already loaded, and perhaps satured with different contents, cannot act so powerfully as one which is free from all sensible impregnation. Nor is this reasoning founded upon theory alone; for it is observed, that Malvern water, which issues from a spring in Worcestershire, remarkable for its uncommon purity, has the property of dissolving the little sabulous stones which are often voided in nephritic complaints. And the solution too, which is a proof of its being complete, is perfectly colourless. Hence this water is drunk with great advantage in disorders of the urinary passages. And during the use of it, the patient's urine is generally limpid, and seldom deposits any sandy sediment. Yet notwithstanding this appearance of transparency, it is certainly at such times loaded with impurities, which are so diluted and dissolved as not to be visible. For it is attended with a strong and fetid smell, exactly resembling that of asparagus. Hoffman mentions a pure, light, simple water in the principality of Henneberg, in Germany, which is remarkable for its efficacy in the stone and gravel; and a water of similar virtues was discovered not many years ago in the Black forest, near Osterod, which upon examination did not afford a single grain of mineral matter. Indeed it is worthy of observation, that most of the springs which were formerly held in great esteem, and were called *holy wells*, are very pure, and yield little or no sediment.

Dr Percival informs us that a gentleman of Manchester, who had been long subject to nephritic complaints, and often voided small stones, was advised to refrain from his own pump-water, which is uncommonly hard, and to drink constantly the soft water of a neighbouring spring; and that this change alone, without the use of any medicine, has rendered the returns of his disorder much less frequent and painful. A lady also, much affected with the gravel, was induced by the perusal of the first edition of Dr Percival's Essay, to try the effect of soft water; and by the constant use of it remained two years entirely free from her disorder.

Dysur. In nephritic cases, distilled water would be an excellent substitute for Malvern water, as the following experiment evinces.

Two fragments of the same calculus nearly of equal weight, were immersed, the one in three ounces of distilled water, the other in three ounces of hard pump-water. The phials were hung up close together in a kitchen-chimney, at a convenient distance from the fire. After 14 days maceration, the calculi were taken out, and carefully dried by a very gentle heat. The former, viz. that which had been immersed in distilled water, was diminished in its weight a grain and a half; the latter had lost only half a grain.

It is the passage of these calculi from the kidneys down into the bladder, which occasions the pain, vomiting, and other symptoms, that constitute what is usually termed a *fit of the gravel* or *stone*.

When an inflammation is actually raised, the disease is known by the name of *nephritis*, and has been already treated of.

As soon as the stone passes through the ureter, and falls into the bladder, the pain and other nephritic symptoms cease; and every thing will remain quiet, either till the stone be carried into the urethra, or until it has remained long enough in the bladder to acquire weight sufficient to create new distress.

If a stone happen to be smooth and of a roundish form, it may lie in the bladder and acquire considerable bulk before it can be perceived by the patient; but when it is angular, or has a rugged surface, even though it may be small in size, yet it seldom fails to raise pain, and occasion bloody urine, or the discharge of a slimy fluid, with tenesmus, and difficulty in making water.

There have been various attempts made to dissolve the stone; and there are certainly some articles which have this effect when applied to them out of the body; but the almost total impossibility of getting these conveyed to the kidneys, renders it extremely doubtful whether a solvent ever will be discovered. Of all the articles employed for this purpose, no one perhaps has had greater reputation than fixed alkaline salt in its caustic state, particularly under the form of the *lixivium causticum*, or *aqua potassæ*, as it is now called: but this being of a very acrid nature, it requires to be well sheathed by means of some gelatinous or mucilaginous vehicle. Veal-broth is as convenient as any for this purpose; and accordingly it is used by those who make a secret of the caustic alkali as a solvent of calculus.

Mr Blackrie, who has taken much pains in this inquiry, has proved very satisfactorily, that Chittrick's nostrum is no other than soap-lees given in veal-broth, which the patients send every day to the doctor, who returns it mixed up with the medicine, in a close vessel secured by a lock.

It is not every case, however, that either requires or will bear a course of the caustic alkali. Some calculi are of that soft and friable nature, that they will dissolve even in common water; and there are cases wherein it appears that the constant use of some very simple decoction or infusion of an insignificant vegetable, has brought away large quantities of earthy matter, in flakes which apparently have been united together in layers to form a stone. Dr Macbride assures

Ephesces. sures us, that a decoction of raw coffee, only 30 berries in a quart of water, boiled till it acquired a deep greenish colour, taken morning and evening to the quantity of eight or ten ounces, with ten drops of sweet spirit of nitre, had the powerful effect of bringing away, in the course of about two months, as much earthy matter in flakes as filled a large tea-cup. The patient was far advanced in years; and, before he began this decoction, had been reduced to great extremities by the continuance of pain and other distressing symptoms: he was purged occasionally with *oleum ricini.*

Very lately the alkali in a mild state, and in a different form, has been much used by many calculous patients, and with great advantage, under the form of what is called *alkaline aërated water*, the aqua supercarbonatis potassæ of the present edition of the Edinburgh Pharmacopœia. For the introduction of this medicine, or at least for its extensive use, we are chiefly indebted to the ingenious physician Dr William Falconer of Bath. He has lately published an account of the *Aqua Mephitica Alkalina*, or solution of fixed alkaline salt, saturated with fixable air, in calculous disorders; which contains a number of cases strongly supporting the benefit to be derived from it. But whether the good effects obtained in these instances are to be explained from its operating as a solvent of calculus, seems to be extremely doubtful. There are indeed cases in Dr Falconer's treatise, of patients in whom, after using it for a considerable time, no stone could be detected by sounding, although it had been discovered in that way before they began the employment of it. But in many instances, the relief has been so sudden, that it may be concluded, that, notwithstanding the ease obtained, the calculus still remained. In such cases, it probably removed from the urine that quality by which it gives to the calculus fresh accretions, producing that roughness of its surface by which it is chiefly capable of acting as a stimulus. For the distressing symptoms resulting from stone are chiefly to be attributed to the inflammatory and spasmodic affections which it induces; and when its surface is least capable of operating as a stimulus, these of course will be least considerable. It is therefore not improbable, that this remedy produces relief, by preventing fresh additions being made to the calculus.

An infusion of the seeds of *daucus sylvestris* sweetened with honey, is another simple and much celebrated remedy; it has been found to give considerable ease in cases where the stomach could not bear any thing of an acrid nature, The leaves of the *uva ursi* were strongly recommended by the late celebrated De Haen; and this, whatever its way of operating may be, seems to have been productive of good effects in some instances. There is no reason to believe that it has any influence in dissolving calculus; and indeed it seems to be chiefly useful in these instances where ulcerations take place in the urinary passages.

In the Edinburgh Medical Commentaries, vol. iii. we have an account of a method used by the inhabitants of Arabia Petræa for curing the stone, to which they are very much subject, and which the author (an English gentleman of experience and candour) affirms he has seen frequently performed with success. By means of a catheter, they inject into the bladder a weak ley of alkali with the purified fat of a sheep's tail, and a proper quantity of opium, all put together. Their catheters are made of gold; and in performing the operation they introduce them quite into the bladder; so that the composition is safely conveyed to the stone without hurting any other part. But when a stone is situated in the kidney, they have no method of cure.

Dysuria.

If this method of curing by injection could be safely practised, it would no doubt have the advantage over that of taking alkalies by the mouth, where the medicine is not only much weakened, but the constitution of the patient runs the risk of being greatly injured. But from some experiments mentioned in the second volume of the Medical Transactions, and still more from the chemical analysis of urinary concretions, lately published by Fourcroy and other modern chemists, it appears that the human calculi are very different from one another in their natures. Some, for instance, will easily yield to an alkaline menstruum, and very little to an acid; while others are found to resist the alkali, and yield to the acid; and some are of such a compact nature, that they yield neither to acids nor alkalies. An attention, however, to the fragments, scales, or films, which the stone may cast off, and also to the contents and sediment of the urine, may lead to the discovery of what solvent is proper, or whether the stone can be dissolved by any. To use either alkalies or acids improperly may be hurtful; though there may be such kinds of calculi as demand the alternate use of acids and alkalies; nay, there may be found calculi of opposite kinds in the same subject.

In such cases as will not allow us to think of dissolving the stony concretions, and where the only object is to palliate and procure ease from time to time, little more can be done than to keep the bowels open occasionally by some gentle cathartic, and wash off as much of the loose gravelly matter and slime as can be removed by such mild diuretic infusions and decoctions as shall be found to pass freely and sit well on the stomach. Persons afflicted with the stone should be careful in respect of their diet, and studiously avoid all heavy and flatulent food, as well as high sauces that are apt to turn rancid. For the same reason, butter and acids are to be shunned; for these often create heartburning, and every thing that offends the stomach raises the nephritic pain; such is the sympathy that obtains between the digestive and the uropoietic organs.

There have been surgeons bold enough to entertain an idea of cutting even into the kidney, in order to extract a stone: this, however, except in cases where an abscess has been formed, and nature points out the way, is both very uncertain and very hazardous. But cutting into the bladder for the same purpose, is an ancient and well known operation, and often crowned with success. A description, however, of this operation belongs to the article SURGERY, to which we refer; and here shall only make this remark, that a surgeon should never begin his operation, until he and his assistants are perfectly satisfied, from actually feeling the stone, that there is one in the bladder; because it has sometimes happened, that when the incision has been made, no stone could be found: and the patient having died in consequence of the operation, and the body

Epischeses. body being opened, it has appeared that the symptoms which occasioned the belief of a stone in the bladder arose from some other cause.

When a dysuria proceeds from any acrimonious matter thrown into the blood, it may be readily cured by bleeding, emollient clysters, cooling and diluting drinks with gum arabic or gum tragacanth, linseed tea, or the warm bath. When it arises from inflammations of the bladder or parts adjoining to it, we are to regard it only as a symptomatic affection; and the remedies used to remove the primary disease will also remove the dysuria. Sometimes it may arise from an ulcer of the bladder; in which case it is generally incurable; a mild nutritious diet will, however, protract the patient's life; and even render that life tolerable, by alleviating symptoms.

401 Genus CXXV. DYSPERMATISMUS.

Difficult Emission *of* Semen.

Dyspermatismus, *Sauv.* gen. 260.
Sterilitas, *Lin.* 171. *Sag.* 211.
Agenesia, *Vog.* 283.

This impediment proceeds generally from obstructions in the urethra, either by tumors in itself, or in the cavernous bodies of the penis; in which case the treatment is the same as in the ischuria urethralis; sometimes it is owing to a kind of epileptic fit which seizes the man in the venereal act; and sometimes the semen, when ejected from the proper receptacles, is again absorbed, or flows into the bladder, and is expelled along with the urine. The last case it is very difficult, or even impossible, to cure; as proceeding from scirrhi, or other indissoluble tumors of the verumontanum, or the neighbouring parts. It is also, in general, incurable. In some it proceeds merely from too violent an erection; in which case emollient and relaxing medicines will be of service; and we have an example of a cure performed by means of these in the first volume of the Edinburgh Medical Essays.

402 Genus CXXVI. AMENORRHOEA.

Suppression *of the* Menses.

Amenorrhœa, *Vog.* 130.
Dysmenorrhœa, *Lin.* 168. *Sag.* 218.

This obstruction, with many other symptoms, as dyspepsia, yellowish or greenish colour of the skin, unusual appetites, &c. constitutes the *chlorosis* already treated of, a disease which seldom or never appears without a suppression of the menses. In Dr Home's Clinical Experiments we find the virtues of several emmenagogues set forth in the following manner. Chalybeates seldom or never succeeded: they were always found more useful in diminishing the evacuation when too violent, than in restoring it when deficient. The tincture of black hellebore proved successful only in one of nine or ten cases, though given to the length of four tea-spoonfuls a-day, which is double the quantity recommended by Dr Mead. Compression of the crural artery, recommended by Dr Hamilton in the Physical and Literary Essays, vol. ii. proved successful only in one of six cases. From the effects produced by this compression, it has the strongest appearance of loading the uterus with blood; from the sensations of the patient it produces the same effects as the approach of the menses, and has every appearance in its favour; yet does not succeed. Dr Home supposes that the uterus is most frequently in too plethoric and inflammatory a state; in which case, this remedy will do more hurt than in a state of inanition; however, he owns, that in the case in which it did succeed, the patient was plethoric and inflammatory. Venesection is recommended as an excellent remedy; the doctor gives three instances of its success, and says he could give many more. It acts by removing the plethoric state of the uterus, relaxing the fibres, and giving the vessels full play; so that their action overcomes all resistance, and the evacuation takes place. It is of no great moment from whence the blood is taken: the saphænic vein has been supposed to empty the uterus most; but it is difficult to get the proper quantity from it, and the quantity of the discharge cannot be so well measured. The powder of savine is a most powerful remedy; and proved successful in three cases out of four in which it was tried. It was given to the quantity of half a dram twice a-day. It is a strong topical stimulus, and seems improper in plethoric habits. Madder-root, according to Dr Home, is a very powerful medicine in this disease; and proved successful in 14 out of 19 cases in which it was tried, being sometimes exhibited in the quantity of two scruples, or a dram, four times a-day. It has scarcely any sensible effects; never quickens the pulse, or excites inflammatory symptoms: on the contrary, the heat, thirst, and other complaints abate; and sometimes these symptoms are removed, though the disease be not cured; but when it succeeds, the menses appear from the third to the 12th day.

We have now considered all those diseases enumerated in Dr Cullen's Nosology, the cure of which is to be attempted chiefly by internal medicines. The other genera either require particular manual operations, or a very considerable use of external applications; and therefore more properly fall under the article Surgery. To this, therefore, we shall refer the genera which fall under the three last orders of the class of locales, viz. the *tumores*, *ectopiæ*, and *dialyses*; and we shall add, by way of Appendix, a few observations on some important affections to which Dr Cullen has not given a place in his system, or which practitioners in general are not agreed in referring to any one particular genus which he has mentioned.

Amenorrhœa.

APPENDIX.

APPENDIX.

ANGINA PECTORIS.

Dr Heberden was the first who described this disease, though it is an extremely dangerous, and, by his account, not very rare affection. It seizes those who are subject to it when they are walking, and particularly when they walk soon after eating, with a most disagreeable and painful sensation in the breast, which seems to threaten immediate destruction: but the moment they stand still, all the uneasiness vanishes. In all other respects the patients at the beginning of this disorder are well, and have no shortness of breath; from which the *angina pectoris* is totally different. After it has continued some months, the fits will not cease instantaneously on standing still; and it will come on not only when the patients are walking, but when they are lying down, and oblige them to rise up out of bed every night for many months together. In one or two very inveterate cases, it has been brought on by the motion of a horse or carriage, and even by swallowing, coughing, going to stool, speaking, or by any disturbance of mind. The persons affected were all men, almost all of whom were above 50 years of age, and most of them with a short neck and inclining to be fat. Something like it, however, was observed in one woman, who was paralytic; and one or two young men complained of it in a slight degree. Other practitioners have observed it in very young persons.

When a fit of this sort comes on by walking, its duration is very short, as it goes off almost immediately upon stopping. If it comes on in the night, it will last an hour or two. Dr Heberden met with one in whom it once continued for several days; during all which time the patient seemed to be in imminent danger of death. Most of those attacked with the distemper died suddenly: though this rule was not without exceptions; and Dr Heberden observed one who sunk under a lingering illness of a different nature.

The *os sterni* is usually pointed to as the seat of this malady. It seems as if it was under the lower part of that bone, and at other times under the middle or upper part, but always inclining more to the left side; and in many cases there is joined with it a pain about the middle of the left arm, which appears to be seated in the biceps muscle.

The appearance of Dr Heberden's paper in the Medical Transactions very soon raised the attention of the faculty, and produced other observations from physicians of eminence; particularly Dr Fothergill, Dr Wall of Worcester, Dr Haygarth of Chester, and Dr Percival of Manchester. It also induced an unknown sufferer under the disease to write Dr Heberden a very sensible letter, describing his feelings in the most natural manner; which, unfortunately, in three weeks after the date of this anonymous epistle, terminated in a sudden death, as the writer himself had apprehended.

The youngest subject that Dr Fothergill ever saw afflicted with this disorder was about 30 years of age; and this person was cured. The method that succeeded with him was a course of pills, composed of the mass of gum pill, soap, and native cinnabar; with a light chalybeate bitter: this was continued for some months, after which he went to Bath several successive seasons, and acquired his usual health: he was ordered to be very sparing in his diet; to keep the bowels open; and to use moderate exercise on horseback, but not to take long or fatiguing walks.

The only symptom in this patient that is mentioned, was a stricture about the chest, which came on if he was walking up hill or a little faster than ordinary, or if he was riding at a very brisk trot; for moderate exercise of any kind did not affect him: and this uneasy sensation always obliged him to stop, as he felt himself threatened with immediate death if he had been obliged to go forward.

It is the sharp constrictive pain across the chest which (according to Dr Fothergill's observation) particularly marks this singular disease; and which is apt to supervene upon a certain degree of muscular motion, or whatever agitates the nervous system.

In such cases as fell under the inspection of Dr Fothergill, he very seldom met with one that was not attended with an irregular and intermitting pulse; not only during the exacerbations, but often when the patient was free from pain and at rest: but Dr Heberden observes, that the pulse is, at least sometimes, not disturbed; and mentions his having once had an opportunity of being convinced of this circumstance, by feeling the pulse during the paroxysm.

But no doubt these varieties, as well as many other little circumstances, will occur in this disease, as they do in every other, on account of the diversity of the human frame; and if those which in general are found to predominate and give the distinguishing character be present, they will always authorise us in giving the name to the disease: thus, when we find the constrictory pain across the chest, accompanied with a sense of strangling or suffocation; and still more, if this pain should strike across the breast into one or both arms; we should not hesitate to pronounce the case an *angina pectoris*.

As to the nature of this disease, it appears to be purely spasmodic: and this opinion will readily present itself to any one who considers the sudden manner of its coming on and going off; the long intervals of perfect ease; the relief afforded by wine and spirituous cordials; the influence which passionate affections of the mind has over it; the ease which comes from varying the posture of the head and shoulders, or from remaining quite motionless; the number of years for which it will continue, without otherwise disordering health; its bearing so well the motion of a horse or carriage, which circumstance often distinguishes spasmodic pains from those which arise from ulcers; and, lastly, its coming on for the most part after a full meal, and in certain patients at night, just after the first sleep, at which time the incubus, convulsive asthma, and other diseases, justly attributed to the disordered functions

tions of the nerves, are peculiarly apt to return or to be aggravated.

From all these circumstances taken together, there can be little doubt that this affection is of a spasmodic nature: but though it should be admitted, that the whole distress in these cases arise from spasm, it may not be so easy to ascertain the particular muscles which are thus affected.

The violent sense of strangling or choking, which shows the circulation through the lungs to be interrupted during the height of the paroxysm; and the peculiar constrictive pain under the sternum, always inclining (according to Dr Heberden's observation) to the left side; together with that most distressing and alarming sensation, which, if it were to increase or continue, threatens an immediate extinction of life; might authorise us to conclude that the heart itself is the muscle affected: the only objection to this idea is, that the pulse is not always interrupted during the paroxysm. The appearances in two of the dissections, favour the opinion that the spasm affects the heart; as in one subject the left ventricle was found as empty of blood as if it had been washed; and in another, the substance of the heart appeared whitish, not unlike a ligament; as it should seem, in both cases, from the force of the spasm squeezing the blood out from the vessels and cavities.

If this hypothesis be allowed, we must conclude that the spasm can only take place in an inferior degree, as long as the patient continues to survive the paroxysm; since an affection of this sort, and in this part, of any considerable duration or violence, must inevitably prove fatal: and accordingly, as far as could be traced, the persons who have been known to labour under this disease have in general died suddenly.

The dissections also show, that whatever may be the true seat of the spasm, it is not necessary for the bringing of it on, that the heart, or its immediate appendages, should be in a morbid state; for in three out of the six that have as yet been made public, these parts were found in a sound state.

On opening the body of the poor gentleman who wrote the letter to Dr Heberden, "upon the most careful examination, no manifest cause of his death could be discovered; the heart, in particular, with its vessels and valves, were all found in a natural condition."

In the case communicated by Dr Percival to the publishers of the Edinburgh Medical Commentaries, "the heart and aorta descendens were found in a sound state." And in Dr Haygarth's patient, "on opening the thorax, the lungs, pericardium, and heart, appeared perfectly sound." Not to mention Dr Fothergill's patient (R. M.), in whose body the only morbid appearance about the heart was a small white spot near the apex. Thus the cause, whatever its nature might have been, was at too great a distance, or of too subtile a nature, to come under the inspection of the anatomist. But there was a circumstance in two of the subjects that is worthy of remembrance; and which shows that the crasis of the blood, while they were living, must have been greatly injured, namely, its not coagulating, but remaining of a cream-like consistence, without any separation into serum and crassamentum.

From all that we have seen hitherto published, it does not appear that any considerable advances have been made towards the actual cure of this anomalous spasm.

The very judicious and attentive Dr Heberden (to whom the public are highly indebted for first making the disorder known) confesses, that bleedings, vomits, and other evacuations, have not appeared to do any good: wine and cordials taken at bed-time, will sometimes prevent or weaken the fits; but nothing does this so effectually as opiates: in short, the medicines usually called *nervous* or *cordial*, such as relieve and quiet convulsive motions, and invigorate the languishing principle of life, are what he recommends.

Dr Wall mentions one patient, out of the 12 or 13 that he had seen, who applied to him early in the disease, and was relieved considerably by the use of antimonial medicines joined with the fetid gum: he was still living at the time the doctor wrote his paper, (November 1772), and going about with tolerable ease. Two were carried off by other disorders; all the rest died suddenly.

Dr Fothergill's directions are chiefly calculated with the view to prevent the disorder from gaining ground, and to alleviate present distress. Accordingly he enjoins such a kind of diet as may be most likely to prevent irritability: in particular, not to eat voraciously: to be very abstemious in respect to every thing heating; spices, spirits, wines, and all fermented liquors: to guard most scrupulously against passion, or any vehement emotions; and to make use of all the usual means of establishing and preserving general health: to mitigate excesses of irritability by anodynes; or pains, if they quicken the circulation: to disperse flatulencies when they distend the stomach, by moderate doses of carminatives; amongst which, perhaps, simple peppermint water may be reckoned one of the safest. But since obesity is justly considered as a principal predisposing cause, he insists strongly on the necessity of preventing an increase of fat, by a vegetable diet, and using every other practicable method of augmenting the thinner secretions.

These were the only means recommended by the practitioners mentioned above for opposing this formidable disease: but Dr Smyth of Ireland has, we are told, discovered that it may be certainly cured by issues, of which Dr Macbride gives the following instance.

"*A. B.* a tall well-made man; rather large than otherwise; of healthy parents, except that there had been a little gout in the family; temperate; being very attentive to the business of his trade (that of a watchmaker), led a life uncommonly sedentary; had, from his boyhood upwards, been remarkably subject to alarming inflammations of his throat, which seized him, at least, once in the course of the year; in all other respects well.

"In 1767, (then 48 years of age), he was taken, without any evident cause, with a sudden and very dispiriting throbbing under the sternum. It soon afterwards increased, and returned upon him every third or fourth week, accompanied with great anxiety, very laborious breathing, choking, a sensation of fulness and distention in the head, a bloated and flushed countenance, turgid and watery eyes, and a very irregular and unequal pulse. The paroxysm invaded

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vaded, almost constantly, while he was sitting at dinner: now and then he was seized with it in the morning, when walking a little faster than usual; and was then obliged to stop, and rest on any object at hand. Once or twice it came on in bed; but did not oblige him to sit up, as it was then attended with no great difficulty in breathing. In the afternoon fits, his greatest ease was from a supine posture; in which he used to continue motionless for some hours, until, quite spent and worn out with anguish, he dropt into a slumber. In the intervals between these attacks, which at length grew so frequent as to return every fourth or fifth day, he was to appearance in perfect health.

"Thus matters continued for more than two years; and various antispasmodics were ineffectually tried for his relief. In 1769, there supervened a very sharp constrictory pain at the upper end of the sternum, stretching equally on each side, attended with the former symptoms of anxiety, dyspnœa, choking, &c. and with an excruciating cramp, as he called it, that could be covered with a crown-piece, in each of his arms, between the elbow and the wrist, exactly at the insertion of the pronator teres; the rest of the limb was quite free. The fits were sometimes brought on, and always exasperated, by any agitation of mind or body. He once attempted to ride on horseback during the paroxysm; but the experiment was near proving fatal to him. The difference of season or weather made no impression upon him. Still, in the intervals, his health was perfectly good; except that his eyes, which before his illness were remarkably strong and clear, were now grown extremely tender: and that his sight was much impaired. He had no flatulency of stomach, and his bowels were regular.

"In this situation, February 22. 1770, he applied to me for assistance. I had seen, I believe, eight or ten of these frightful cases before. Two of the patients dropt dead suddenly. They were men between 40 and 50 years of age, and of a make somewhat fleshy. The fate of the others I was not informed of; or, at least cannot now recollect.

"Having found the total inefficacy of blisters and the whole class of nervous medicines in the treatment of this anomalous spasm, I thought it right to attempt the correcting or draining off of the irritating fluid in the case now before us. To this purpose, I ordered a mixture of lime-water with a little of the compound juniper-water, and an alterative proportion of Huxham's antimonial wine: I put the patient on a plain, light, perspirable diet; and restrained him from all viscid, flatulent, and acrimonious articles. By pursuing this course, he was soon apparently mended; but after he had persisted regularly in it for at least two months, he kept for some time at a stand. I then ordered a large issue to be opened on each of his thighs. Only one was made. However, as soon as it began to discharge, his amendment manifestly increased. The frequency and severity of the fits abated considerably: and he continued improving gradually, until, at the end of 18 months he was restored to perfect health: which he has enjoyed, without the least interruption, till now, except when he has been tempted (perhaps once in a twelvemonth) to transgress rules, by making a large meal on salted meat, or indulging himself in ale or rum-punch, each of which never failed to disorder him from the beginning of his illness: and even on these occasions, he has felt no more than the slightest motion of his former sufferings; insomuch that he would despise the attack, if it did not appear to be of the same stock with his old complaint. No other cause has had the least ill effect on him.

"Though rum was constantly hurtful, yet punch made with a maceration of black currants in our vulgar corn-spirit, is a liquor that agrees remarkably well with him.

"He never took any medicine after the issue began to discharge; and I have directed that it shall be kept open as long as he lives. The inflammations of his throat have disappeared for five years past; he has recovered the strength and clearness of his sight; and his health seems now to be entirely re-established."

Dr Macbride, in a letter to Dr Duncan, published in the Edinburgh Medical Commentaries, gives the following additional observations on this disease.

"Within these few weeks I have, at the desire of Dr Smyth, visited, three or four times, a very ingenious man who keeps an academy in this city, of about 34 years of age, who applied to the doctor for his advice in January last.

"I shall give you his symptoms as I had them from his own mouth, which appear to me to mark his case to be an angina pectoris, and as deplorable as any that I have read of. It was strongly distinguished by the exquisite constrictory pain of the sternum, extending to each of his arms as far as the insertion of the deltoid muscle, extreme anxiety, laborious breathing, strangling, and violent palpitation of the heart, with a most irregular pulse. The paroxysms were so frequent, that he scarcely ever escaped a day, for six or seven years, without one. They were usually excited by any agitation of mind or body, thought slight. He had clear intervals of health between the fits. The distemper seems hereditary in him, as he says his father was affected in the same manner some years previous to his death. He has a strong gouty taint, which never showed itself in his limbs; and he has led a life of uncommon sedentariness, from intense application to mathematical studies, and attention of mind, and passion, even from his boyish years. These circumstances may, perhaps, account for his having been taken with this disease at so early an age as 17.

"A large issue was immediately opened in each of his thighs. In a month afterwards he began to mend, and has gone on improving gradually. He can now run up stairs briskly, as I saw him do no later than yesterday, without hurt; can bear agitation of mind; and has no complaint, excepting a slight oppression of the breast, under the sternum, which he feels sometimes in a morning, immediately after dressing himself, and which he thinks is brought on by the motion used in putting on his clothes; though for a complete week preceding the day on which I saw him last, he told me that he had been entirely free from all uneasiness, and was exulting that he had not had such an interval of ease for these last seven years.

"Doctor Smyth also showed me, in his *adversaria*, the case of a gentleman who had been under his care in 1760, which he had forgotten when my book went

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went to the press, and which he was reminded of the other day by a visit from his patient. It was a genuine angina pectoris, brought on by a very sedentary life, and great vexation of mind, clearly marked by the exquisite pain under the sternum, that extended acutely to the upper extremities, particularly along the left arm, together with the other symptoms of dyspnœa, anxiety, palpitation of the heart, &c. recited in the case above. The disorder went off in 1762, by large spontaneous discharges from the piles, but returned upon him severely in 1765. Issues in his thighs were then recommended to him, but not made. But, whether it was by the persuasion of some friend, or of his own accord, he went into a course of James's powder, in small alterative doses, combined with a little castor and asafœtida. This he persisted in for about six weeks; in the meanwhile, he had large acrimonious gleetings from the scrotum, and a plentiful discharge of ichor from the anus.—From this time he began to find his complaints grow less and less distressing, and he has now been totally free from them for six years past.

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This species of fever, as its name imports, is peculiar to women in childbed; and is usually the most fatal of all the disorders to which the sex is liable. But, notwithstanding the prevalence of it in all ages, its real nature has remained, to the present time, a subject of much dispute and uncertainty. The critical period of its invasion, when febrile commotions are apt to be excited by various accidents, and the equivocal symptoms which accompany it, have even afforded room for questioning whether it be a primary or a secondary disease. Some writers have considered it as proceeding entirely from an inflammation of the uterus; others have imagined it to be the consequence of an obstruction to the secretion of the milk; while the greater number has been inclined, for reasons equally if not more plausible, to impute it to a suppression of the lochia. If we examine this fever attentively, however, according to its natural course, and independently of all the accidental concomitant symptoms with which it is not essentially connected, we may safely pronounce it to be a primary disease of a particular nature, and perhaps not the necessary consequence of any of the causes above mentioned.

This fever is most generally incident to women within 48 hours after delivery, though it may supervene on the fourth or fifth day, and sometimes considerably later. It is preceded, like other fevers, by a rigor, which is commonly violent; and when happening during the time of labour, may be confounded with the pains of parturiency. In its earlier stage it is attended with the signs of inflammation. A great pain is felt in the back, hips, and the region of the uterus; which, in the part last mentioned, is accompanied with the sense of heat and throbbing. A sudden change in the quality or quantity of the lochia now also takes place; the patient is frequently troubled with a tenesmus; and the urine, which is very high-coloured, is discharged in small quantity and with pain. At the first attack of the fever, the woman is generally seized with a vomiting of porraceous matter, as in the *cholera morbus*, to which disease it then bears a strong resemblance.—But instead of this symptom, there is sometimes only a nausea, or loathing at the stomach, with a disagreeable taste in the mouth. The belly swells to a considerable bulk, and becomes susceptible of painful sensations from the slightest impression. The tongue is generally dry, though sometimes moist, and covered with a thick brownish fur. When the fever has continued a few days, the symptoms of inflammation usually subside, and the disease acquires a more putrid form. At this period, if not at the very beginning of the disorder, a bilious or putrid diarrhœa, of a dangerous and obstinate nature, supervenes, and accompanies it through all its future progress; each motion to stool being preceded by a temporary increase, and followed by an alleviation of pain. The patient usually nauseates all kind of food and drink, except what is cold and acidulated. A brown or blackish sordes, the consequence of putrid exhalations, adheres to the edges of the teeth; a troublesome hiccough is at length produced, which greatly exasperates the pains of the abdomen; petechiæ or vibices also appear, with sometimes a miliary eruption, but which produces no mitigation of the disease. Through the whole course of the fever, the patient is affected with great anxiety and dejection of spirits.

Such in general is the course of the puerperal fever; the symptoms of which, however, may be often varied, according to the constitution of the patient, the degree of the disease, and its earlier or later invasion. When the woman is naturally weak, or her strength has been greatly reduced by immoderate evacuations after delivery; when the disease is violent, and immediately follows that period; its progress and termination are proportionally rapid and fatal. In such unfortunate circumstances, many have been known to expire within 24 hours from the first attack of the disease; nay, there are some instances where the rigor has concluded the scene. The catastrophe, however, is most generally suspended for some days; and the number of these is variable, though the 11th from the commencement of the fever may justly be fixed as the period which is usually decisive. In whatever stage of the disease an unfavourable termination may happen, it would seem as if the commencement of the patient's recovery were not marked by any critical revolution of the fever, as depending on an alteration of the humours; but that the cure is gradually effected, either by a spontaneous vomiting, or a long-continued discharge by stool of that porraceous matter, the existence of which in the stomach is usually evinced at the first attack of the disease. The most unfavourable prognostic, therefore, arises from such a weakness of the patient as renders her unable to support so tedious an evacuation as that by which the fever is overcome. When the lochia return to their former state, when the swelling and tenderness of the abdomen abate, and there is a moisture on the skin, we have reason to hope for a happy termination of the disease.

Though the puerperal fever may generally be ascertained from the description which has been given, and chiefly by that remarkable tenderness of the abdomen which particularly distinguishes it: yet, as some of its symptoms may be confounded with those arising from other diseases, and which require a different method of of cure, it will be proper to mention here the circumstances by which it may be known with greater certainty.

The pains of the abdomen, attending the childbed fever, may be distinguished from those called *after-pains*, by their uninterrupted continuance through the course of the disease, though sometimes they suffer exacerbations; whereas, in the latter, they often totally intermit. They are also distinguished by the absence of fever with concomitant symptoms in the one, and their evident existence in the other.

Many circumstances evince a dissimilarity between the puerperal and miliary fevers, notwithstanding the symptoms of anxiety and oppression are common to both; insomuch that the nature of the approaching disease may be ascertained at the very commencement of its attack. In the puerperal fever the rigor is more violent, of longer duration, and not interrupted, as it is in the other. The pulse is fuller and stronger; the skin is more hot; and the tongue, whether moist or dry, though generally the latter, is not of a white, but brownish appearance; and the urine is also higher coloured. Eruptions, which are critical in miliary fevers, procure no mitigation of the puerperal fever, and cordials generally increase it.

When the original attack of the puerperal fever happens to coincide with the febrile commotion which is excited in childbed women by the milk, the nature of it may at first be misapprehended; but the concomitant symptoms, and greater violence of the disease, must in a short time dissipate such an error.

From all the most accurate accounts of this disease, and from the period at which it generally commences, there seems reason to conclude, that it owes its rise more immediately to accidents after delivery. For it is allowed that it may follow a labour under the best and most favourable circumstances, though endeavours to dilate the os internum are supposed frequently to produce it. The more immediate causes generally assigned by authors are a stoppage of perspiration, the too free use of spices, and the neglect of procuring stools after delivery; sudden frights, too hasty a separation of the placenta, and binding the abdomen too tight. The putrid appearance, however, which this disease so soon assumes, affords ground to suspect that the predisposing cause of it is a vitiated state of the humours; for it is generally observed to be most prevalent in an unhealthy season, and among women of a weakly and scorbutic constitution. But from its prevalence in some particular hospitals, while others in the same city are entirely free from it, there can be little doubt that it is often communicated by contagion from one female to another. This opinion is corroborated also by many other circumstances; particularly by the means by which it has been removed from hospitals. It would seem, however, that this contagion does not act on the female system without a certain predisposition, and that this predisposition is induced by those changes to which the female habit is subjected in consequence of delivery.

Within these few years this fever has been treated of by several writers, most of whom have differed from each other in their sentiments of the nature of the disease. The first in the order of publication is Dr Denman, who seems to be of opinion, that it may derive its origin either from a redundancy or too great acrimony of the bile, the secretion of which appears to be much interrupted in the time of gestation. In Dr Manning's treatise on this fever, he mentions its being highly probable that such a cause contributes greatly to produce the disease, especially where the putrid tendency of the humours is increased by unwholesome air and diet.

It has likewise been the fate of the puerperal fever, that no disease has more divided the sentiments of physicians in regard to the method of cure. The apparent indications and contra-indications of bleeding, and other remedies, arising from the complication of inflammatory and putrid symptoms; the equivocal appearance of the vomiting and purging, as whether they be critical or symptomatical; and the different causes whence symptoms similar to each other may arise in pregnant women; all these circumstances concur to involve the subject in great obscurity and indecision. If we carefully attend to the several characteristics of the disease, however, so as to be able to distinguish it from every other puerperal complaint, and observe at the same time the usual manner of its declension, our judgment may be guided in the method of cure by the salutary efforts of nature. But, in order to obtain a clearer view of the genuine indications, it will be proper to consider them under the several lights in which they have been generally agitated by authors.

One of the most essential points to be ascertained in the cure of the childbed fever, respects the propriety of bleeding. A free use of the lancet has been generally regarded as the most successful expedient in practice; and there are some instances of critical hæmorrhages which would seem to confirm its utility. But Dr Denman thinks we may safely affirm from experience, that for one who will be benefited by large bleeding, a much greater number will be injured, and that even almost irretrievably Nor can this seem surprising, when we consider the situation of childbed women. In most, the evacuations consequent upon delivery are sufficient to diminish any undue superabundance of the fluids; and if, as frequently happens, the disease be produced by too hasty a separation of the placenta, the consequence of which is generally a very copious discharge of blood, we can never suppose that nature will be assisted in overcoming the febrile commotion, by the farther evacuation of the vital fluid, through the defect of which she is now rendered unequal even to the ordinary support of the animal œconomy. We may appeal to every practical physician, how much he has known the pulse to sink, and what a train of nervous symptoms he has observed to succeed an excess of the discharge above mentioned. Besides, it is an axiom in physic, that a remedy which cures any disorder, will always prove sufficient to prevent it; and therefore, if bleeding were the proper cure in the childbed fever, the disease ought to have been prevented by a large evacuation of blood, when that happened previous to its attack. Experience, however, in this, as in all other diseases, is the only unerring guide we can follow; and whoever regulates his practice by fact and observation, will be convinced that bleeding, especially in a large quantity, is, in general, very far from being attended with success. Bleeding

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is seldom proper, except in women of plethoric constitutions, and in whom the signs of inflammation rise high. Nor even in such patients ought it to be repeated without great caution, and the existence of strong indications. Bleeding, when used in proper circumstances, may unquestionably palliate the fever; but that it often shortens the duration of it, appears to be a matter of much doubt. On this account the practice becomes still more suspicious and exceptionable, when we consider that by venesection improperly used the patient's strength may be so far reduced as not to support the tedious looseness by which the disease is generally carried off. Though bleeding, however, ought in general to be used with great caution, there are certainly many cases in which it is both necessary and advantageous.

The genuine nature and effects of the looseness in this disease, is another controverted point of the highest importance, and which merits the most attentive inquiry. Physicians, observing that women who die of the puerperal fever are generally molested with that evacuation, have been induced to consider this symptom as of the most dangerous and fatal tendency; and what, therefore, we should endeavour by every means to restrain. In this opinion, however, they would seem to have been governed by too partial an observation of facts. For experience certainly authorises the assertion, that more women appear to have recovered of the childbed fever, through the intervention of a diarrhœa, than have been destroyed by that cause. If it also be considered, that purging is usually almost the only sensible evacuation in the more advanced state of the disease, and is that which accompanies it to its latest period, we shall have the strongest reason to think that it is critical rather than symptomatical, and ought therefore to be moderately supported, instead of being unwarily restrained Nay, the advantage which is found to attend vomiting as well as purging in the earlier stages of the disease, would seem to evince that the matter discharged by these evacuations is what chiefly foments the disease. Emetics and purgatives, therefore, in the opinion of Dr Manning, are the only medicines on which any rational dependence is to be placed in this fever; at least, they are certainly such as are found the most successful. It is an established rule in practice, to prescribe a vomit at the beginning of every fever attended with any nausea or loathing of the stomach, and where there is not any reason to apprehend an inflammation of that organ. Nor does the state of childbed women afford the smallest ground for prohibiting our recourse to the same expedient in answering a similar indication.

It is so seldom a physician is called during the rigor preceding the puerperal fever, that he has few opportunities of trying the effects of remedies in that early state of the disease. When such occur, however, we should endeavour as much as possible to abate and shorten that period, as the succeeding fever is generally found to bear a proportion to the violence and duration of it. For this purpose, warm diluting drinks should be plentifully used, with a small quantity of volatile spirits or brandy. When Dr Manning apprehended such an accident, he sometimes ordered the nurse to give immediately a dish or two of warm sack-whey; taking care that it was not too strong, which is a caution that ought always to be remembered; for though a free use of the more cordial and spirituous kinds of liquors might perhaps soon abate the rigor, there is danger to be feared from their influence on the approaching fever, especially in women of a strong and healthy consitution. In all cases, warm applications to the extremities, such as heated bricks, towels, or toasted grains in a linen bag, may be used with perfect safety, and some advantage.

When the hot fit is advanced, the first thing Dr Manning orders is some emollient injection, as chicken-water, or water and milk, which ought to be frequently repeated through the course of the disease. These prove beneficial, not only by promoting the discharge from the intestines, which seems in fact to be the solution of the disease; but also by acting as a kindly fomentation to the uterus and adjacent parts. With this intention they are particularly serviceable when the lochia are suppressed. Great care, however, is requisite in administering them, on account of the tenderness and inflammatory disposition, which at that time render the parts in the pelvis extremely susceptible of pain.

The next step in the method of cure ought to be to promote the discharge of the morbid matter both by the stomach and intestines. This intention may be answered by a remedy prescribed by Dr Denman—Two grains of tartrite of antimony rubbed up with a scruple of the powder of lapilli cancrorum.

Of a powder thus prepared, Dr Denman gives from two to six grains, and repeats it as circumstances require. If the first dose do not procure any sensible operation, he repeats it in an increased quantity at the end of two hours, and proceeds in that manner; not expecting any benefit but from its sensible evacuation.

Should the disease be abated, but not removed, (which sometimes happens), by the effect of the first dose, the same medicine must be repeated, but in a less quantity, till all danger be over. But if any alarming symptoms remain, he does not hesitate one moment to repeat the powder, in the same quantity as first given; though this be seldom necessary, if the first dose operates properly.

It is to be observed, says Dr Denman, that as the certainty of cure depends upon the proper repetition of the medicine, the method of giving it at stated hours does not appear eligible. If the first dose produce any considerable effect by vomiting, procuring stools, or plentifully sweating, a repetition of the medicine in a less quantity will seldom fail to answer our expectations; but great judgment is required in adapting the quantity first given to the strength of the patient and other circumstances. We are not to expect that a disease which from the first formation carries so evident marks of danger, should instantly cease, even though a great part of the cause be removed.

Frequent doses of the saline draughts ought also to be given, which not only promote the evacuation by the instestines, but likewise increase the salutary discharges of urine and perspiration. These medicines are particularly serviceable in subduing the remains of the fever, after its violence has been broken by the more efficacious remedies above mentioned; but when they are used even in the decline of the disease, gentle laxatives of rhubarb and magnesia, as advised by Dr Denman,

Denman, ought to be frequently interposed, since, as he justly observes, without stools we can do little service.

Although the discharge by the intestines appears to have the most salutary effect in this disease; yet when the stomach has not been properly unloaded of offensive matter, though a great nausea and sickness had indicated the expediency of such an evacuation at the beginning of the fever, the continuance of the looseness is sometimes so long protracted as in the end to prove fatal. In this alarming state of the disease, when the stools are very frequent and involuntary, and all appearances threaten danger, Mr Denman says, that a clyster of chicken-water injected every one, two, or three hours, or as often as possible without fatiguing the patient too much, with a cordial diaphoretic draught taken every six hours, has produced better effects than could be expected.

While these medicines are employed, we should endeavour to mitigate the pains of the belly by relaxing applications. During the course of the disease, the patient ought to drink freely of diluting liquors, and abstain from every thing of a heating quality, unless great faintness should indicate the use of a small quantity of some cordial medicine.

Such is the practice recommended in this disease by Dr Denman. We shall now take a cursory view of the sentiments of succeeding writers on this subject.

According to Dr Hulme, the proximate cause of the puerperal fever is an inflammation of the intestines and omentum; for the confirmation of which opinion he appeals to dissections. He supposes the chief predisponent cause of the disease to be the pressure of the gravid uterus against the parts above mentioned. The omentum, says he, in the latter stage of pregnancy, must either be flat, which is its natural situation, or be rumpled or carried up by the gravid uterus in folds or doublings. When the latter is the case, which he observes is probably not seldom, the danger of a strangulated circulation will be greater.

Mr White, who has also written on this disease, judiciously remarks, that were Dr Hulme's hypothesis well founded, the disorder ought rather to take place before delivery, and be immediately removed at that period: That it would likewise most generally happen to women at their first labour, when the abdominal muscles are less yielding, and the pains more violent; the contrary of which is most frequently experienced to be the case.

It also deserves to be remarked, that, upon Dr Hulme's supposition, we cannot account for the disease being more common and fatal in large towns and in hospitals, than in the country and private practice, while other inflammatory disorders are more endemic among those who live in the latter than the former situation. Even admitting the friction of the intestines and omentum against the uterus to be as violent as Dr Hulme supposes, is it not highly improbable, that any inflammation could be occasioned by the pressure of such soft substances upon each other? Or, were this effect really produced, ought not the puerperal fever to be more common and fatal after the most laborious deliveries? But this observation is not supported by experience.

Dr Hulme, in favour of his own hypothesis, alleges that it gives a satisfactory answer to the question, "Why all lying-in women have been, and ever will be, subject to this disease?" In this proposition, however, the doctor supposes such an universality of the disease as is not confirmed by observation. It is affirmed upon undoubted authority, that in many parts of Britain the puerperal fever is hardly known; whereas, were it really produced by the causes he assigns, it would be equally general and unavoidable.

But how peculiar soever this author's sentiments are in respect of the proximate cause of this disease, they have not led him to any method of cure different from the established practice. On this subject Dr Hulme divides his observations into two parts; comprehending under the former the more simple method of treatment, and under the latter the more complex. He sets out with remarking, that the patient being generally costive at the beginning of the disease, an emollient opening clyster will often give immediate relief; but if this should not prove effectual, recourse must be had to cathartics. Those which he found answer his purpose best, were the *sal catharticus amarus*, the *oleum ricini*, emetic tartar, and antimonial wine. When the bowels have been sufficiently cleared and the pain abates, he advises encouraging a gentle diaphoresis by medicines which neither bind the body nor are heating; such as small doses of ipecacuan, emetic tartar, and antimonial wine, combined with an opiate in a moderate dose, and given once or twice in the course of 24 hours; administering the saline draughts in the intermediate spaces. If, preceding or during this course, a sickness at stomach or vomiting attend, he advises assisting the efforts of nature, by drinking plentifully of chamomile tea, warm water, or any other diluting liquor. He concludes with recommending a cooling regimen, rest of body, and tranquillity of mind; prohibiting all kinds of bandage upon the abdomen, and enjoining particular attention to the state of the bowels, which ought to be kept gently open for some time, even after the disorder seems to be gone off, till the patient be quite out of danger.

So much for the simple treatment: we now proceed to the second part, where he describes the method of practice when the disease is in its more irregular and complicated state.

When a diarrhœa accompanies the disease, he observes that it ought by no means to be checked, but supported, by ordering the patient to drink plentifully of mild aperient liquors. If the pain of the hypogastric region be attended with stitches in the sides or over the pit of the stomach, and a pulse that resists the finger pretty strongly, he remarks that bleeding would then be highly necessary: declaring, however, his opinion, that, in the puerperal fever, bleeding is to be considered only as a secondary means of relief, though the first in point of time; and it ought to be advised with great caution; and that the greatest dependence is always to be placed upon evacuations by stool.

Mr White imputes the puerperal fever to a putrescent disposition of the humours, contracted during pregnancy, and fomented by the hot regimen commonly used by women in childbed. In conformity to this opinion, the chief means which he recommends for preventing the disease is a cool regimen and free circulation

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tion of air, which he evinces to be of the greatest importance. In respect of bleeding, he informs us, that, upon the strictest inquiry, he cannot find that those who have bled the most copiously have had the greatest success, either in private or hospital practice. He even seems to question the propriety of this evacuation in any case; but approves of emetics, cathartics, and clysters, for cleansing the *primæ viæ*, and likewise of such medicines and diet as will correct the putrid humours: adding, that an upright posture and free ventilation are at all times useful, and absolutely necessary, both for the prevention and cure of the disease.

Another writer who treats of the childbed fever is Dr Leake, who has published the result of his observations on this disease from April 1768 to the autumn of the year 1770; but chiefly from December 1769 to May 1770, during which period the childbed fever prevailed much about London.

Dr Leake tells us that this fever generally commenced the evening of the second or morning of the third day after delivery, with a rigor or shivering fit. Sometimes it invaded soon after delivery; and at other times though rarely, it has seized so late as the fifth or sixth day. Now and then it seemed to be occasioned by catching cold, or by errors in diet; but oftener by anxiety of mind. Sometimes the thirst was great; though the tongue had, in general, a better appearance at the beginning than is common in other fevers. It was seldom ever black or very foul: but, as the disease advanced, became white and dry, with an increase of thirst; and at last was of a brownish colour towards the root, where it was slightly covered with an inspissated mucus. The loss of strength was so great and sudden, that few of the patients could turn in bed without assistance, even so early as the first or second day after the attack. The lochia, from first to last, were not obstructed, nor deficient in quantity; neither did the quality of this discharge seem to be in the least altered from its natural state; a presumption, says the author, that the uterus was not at all affected. Of this he was convinced by making a considerable pressure above the pubes with the hand, which did not occasion pain; but when the same degree of pressure was applied higher, between the stomach and umbilical region, it became almost intolerable. A perfect crisis seldom if ever happened in this fever, which he imputes to the great oppression of the vital powers, whereby they were rendered unable to produce such an event. When the disease proved mortal, the patient generally died on the 10th or 11th day from the first attack. In those who died of the fever, the omentum was found suppurated; an inflammation of which part, or of the intestines, Dr Leake concludes to be the proximate cause of the disease.

In consequence of this idea of the cause of the disease, Dr Leake affirms that venesection is the only remedy which can give the patient a chance for life. But, though it be the principal resource to be depended upon at the beginning of the fever, he observes that it will seldom prove of service after the second or third day; and if directed yet later, will only weaken and exhaust the patient; when, matter having begun to form in the omentum, the progress of the disease can no longer be prevented by that evacuation. At this period the blood begins to be tainted by the absorption of the purulent fluid; and the fever, from being inflammatory, is changed into a putrid nature.

After bleeding in such a quantity as the symptoms require, he advises that the corrupted bile be evacuated and corrected as soon as possible; that the diarrhœa, when excessive, be restrained by emollient anodyne clysters and gentle sudorifics, or even by opiates and mild astringents, when the patient's strength begins to sink under the discharge; and, lastly, that where the signs of the putrefaction or intermission take place, antiseptics and the cinchona may be administered.

The great uniformity of the symptoms in all Dr Leake's patients might authorise an opinion, that the fever which he describes was in a great measure a disease *sui generis*, and depended much upon the constitution of the air preceding and during the period in which the fever prevailed.

Dr Kirkland has also made judicious observations on this subject. He rejects the opinion that the puerperal fever is a disease *sui generis*, and arises always from the same cause. The particular situation of childbed women, he acknowledges, occasions a similarity in the appearance of all the febrile symptoms: but he affirms that the same kind of fever may be produced by various causes; for instance, by an inflammation of the uterus or abdomen, by putrid blood or other matter, and putrid miasms. The symptoms, he observes, will vary according to the time of seizure. If the fever happen in three or four days after delivery, all the symptoms usual to the situation of the patient will make their appearance; but if it do not invade till the milk has been secreted, and the lochial discharge be nearly finished, the symptoms, if the breasts are properly drawn, will, for the most part, be those only which are common to that kind of disorder by which the fever has been produced.

With respect to the cure of puerperal fevers, Dr Kirkland advises the antiphlogistic method when they arise from inflammation; but when this method fails of success, and a diarrhœa supervenes, the disease has changed its nature, having become more or less putrid, and requires a very different treatment.

His observations relative to the management of the diarrhœa merit attention. No one, says he, would purge and bleed to cure the colliquative fever arising from the absorption of matter in large wounds; and yet the only difference is, that in the puerperal fever the matter absorbed from the uterus, &c. acts with more violence, because the blood is commonly thinner and the habit in a more irritable state. We see, continues he, that absorbed matter purges as effectually as if any purging medicine had been given by the mouth; and may we not therefore do harm by additional purging, when there has been a large evacuation, especially as purges in this case are incapable of entirely removing the *fomes morbi*?

He considers cinchona as the principal remedy, as soon as the pulse sinks, the heat is lessened, and the stomach will bear it. If this increase the diarrhœa beyond moderation, he joins with it small doses of laudanum; but if the diarrhœa should entirely stop without the fever going off, in place of laudanum he advises a proper quantity of rhubarb. Should the diarrhœa, notwithstanding the use of the medicines proposed, become

 come so violent as to endanger the patient, he agrees with Mr White in recommending the columbo root, which is a warm cordial, and removes the irritability of the stomach and intestines more powerfully than any other bitter he knows.

Of this disease also, as it appeared in Derbyshire and some of the adjacent provinces, an account has been published by Dr Butter. Concerning the causes and nature of the disease, he observes, that pregnancy seems to add much to the natural sensibility of the female constitution; because at this period women are often subject to a train of nervous symptoms, which never molest them at other times. During gestation likewise, the appetite is for the most part keen, while the digestion appears to be impaired; and this weakness is increased not only by improper food, of which the woman is frequently desirous, but also by the inactivity attending her situation. To these circumstances, it is added, that the intestinal passage being interrupted by the uterine pressure, costiveness generally prevails. From the several observations here enumerated, Dr Butter concludes, that the proximate cause of the puerperal fever is a spasmodic affection of the first passages, with a morbid accumulation in their cavity; and upon this supposition he endeavours to account for the various symptoms of the disease.

In treating of the method of cure, he lays down two indications; the former of which is to promote two, three, or four stools daily, in a manner suited to the strength of the patient, till such time as they resume a natural appearance. The second indication is to relieve all uneasy symptoms, such as heat, thirst, headach, &c.

With respect to the opinion entertained by Dr Butter of the cause of the puerperal fever, it nearly coincides with that of Mr White. But however plausible it may appear, we are not entirely satisfied that a disease attended with so peculiar symptoms as the puerperal fever can depend principally upon an irritability, which is not restricted either to the pregnant or puerperal state.

The late Dr Thomas Young professor of midwifery in the university of Edinburgh, although he published nothing on the subject of the puerperal fever, wrote a very ingenious dissertation respecting it, which was read in the Philosophical Society of Edinburgh. In that dissertation, after giving a very accurate account of the symptoms of the disease, which coincides very nearly with the account given by others, he endeavours to show, that the *puerperal fever*, strictly so called, is in every instance the consequence of contagion; but he contends, that the contagious matter of this disease is capable only of producing its effect, in consequence of a peculiar predisposition given by delivery and its consequences. In support of this doctrine, he remarks, that for many years the disease was altogether unknown in the lying-in ward of the Royal Infirmary at Edinburgh; but that after it was once accidentally introduced into the hospital, almost every woman was in a short time after delivery attacked with it; although prior to delivery, she may have lain, even for weeks together, not only in the same ward with the infected, but even in the very next bed. He remarks, that it was only eradicated from the hospital in consequence of the wards being entirely emptied, thoroughly ventilated, and new painted. After these processes, puerperal females in the hospital remained as free from this disease as formerly. The puerperal fever, according to Dr Young, has very generally a strong tendency to the typhoid type; although he allows, that in the beginning it is not unfrequently attended with inflammatory symptoms, and even with topical inflammation, particularly in the intestinal canal. On this idea, he considers the puerperal fever as admitting of the same variety of treatment with other affections depending on contagion, in which sometimes an inflammatory, sometimes a putrescent tendency, prevails; such, for example, as smallpox or erysipelas. But from the prevailing putrescent tendency in this affection, he considers the free access of cool air, with the liberal use of antiseptics, as being very generally requisite.

It deserves to be remarked, that though the several writers who treat of this subject have conducted their method of cure conformably to their particular idea of the cause of the disease, respecting which their sentiments are very different, they seem to have been equally successful in the treatment of their patients. Indeed the several writers differ less from each other in their method of cure than might be expected, where so great an opposition of theoretical sentiment prevails. For after endeavouring to establish indications correspondent to their particular systems, those who contend for the expediency of promoting the intestinal discharge, dissuade not from having recourse to phlebotomy when the disease is attended with inflammatory symptoms; while, on the other hand, the most strenuous advocates for bleeding admit the utility of the former evacuation. It appears, therefore, that a due regulation of the alvine discharge is necessary through the whole course of the fever, but venesection only sometimes.

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Those infesting the human body are chiefly of three kinds: the *ascarides*, or small round and short white worms; the *teres*, or round and long worm; and the *tænia*, or tape-worm.

The *ascarides* have usually their seat in the rectum.— 406
The *teretes* or *lumbrici* are about a span long, round and smooth: they are seated for the most part in the upper small intestines; but sometimes they are lodged also in the stomach, and in any part of the intestines, even to the rectum.—The tape-worms are from two to forty 407
feet long, according to the testimony of Platerus; they generally possess the whole tract of the intestines, but especially the ileum: they very much resembe a tape in their appearance, whence the name of *tape-worm*: but another species of this genus, from the resemblance of each joint to a gourd seed, has the name of the *gourd-worm*.

In the Medical Transactions, vol. i. Dr Heberden gives a very accurate account of the symptoms produced by the *ascarides*, from an eminent physician who was troubled with them all his life. They brought on an uneasiness in the rectum, and an almost intolerable itching in the anus; which sensations most usually came on in the evening, and prevented sleep for several hours. They were attended with heat, sometimes so considerable as to produce a swelling in the rectum both

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both internally and externally; and if these symptoms were not soon relieved, a tenesmus was brought on, with a mucous dejection. Sometimes there was a griping pain in the lower part of the abdomen, a little above the *os pubis*. If this pain was very severe, a bloody mucus followed, in which there were often found ascarides alive. They were also sometimes suspected of occasioning disturbed sleep, and some degree of headach.

On this case Dr Heberden observes, that the general health of the patient did not seem to have suffered from the long continuance of the disease, nor the immediate inconveniences of the disorder itself to have increased. "It is (says he) perhaps universally true, that this kind of worms, though as difficult to be cured as any, yet is the least dangerous of all. They have been known to accompany a person through the whole of a long life, without any reason to suspect that they had hastened its end. As in this case there was no remarkable sickness, indigestion, giddiness, pain of the stomach, nor itching of the nose, possibly these symptoms, where they have happened to be joined with the ascarides, did not properly belong to them, but arose from some other causes. There is indeed no one sign of these worms, but what in some patients will be wanting."

The above-mentioned patient used purging and irritating clysters with very little success. One dram and a half of tobacco was infused in six ounces of boiling water; and the strained liquor being given as a clyster, occasioned a violent pain in the lower part of the abdomen, with faintness and a cold sweat: this injection, though retained only one minute, acted as a smart purge, but did little or no good. Lime-water was also used as a clyster; which brought on a costiveness, but had no good effect. Six grains of salt of steel were dissolved in six ounces of water, and injected. This clyster in a few minutes occasioned an aching in the rectum, griped a little without purging, and excited a tenesmus. Some few ascarides were brought off with it; but all of them were alive. The uneasy sensation in the rectum did not abate till some warm milk was thrown up. Whenever the tenesmus or mucous stools were thought worth the taking notice of, warm milk and oil generally gave immediate relief. If purging was necessary, the lenient purges, such as manna with oil, were, in this particular case, made use of: rhubarb was found too stimulating.—But, in general, the most useful purge, and which therefore was most usually taken, was cinnabar and rhubarb, of each half a drachm: this powder seldom failed to bring away a mucus as transparent as the white of an egg, and in this many ascarides were moving about. The cinnabar frequently adhered to this mucus, which did not come off in large quantities, when a purge was taken without cinnabar. Calomel did no more than any other purge which operates briskly would have done; that is, it brought away ascarides, with a great deal of mucus. Oil given as a clyster sometimes brought off these animalcules: the oil swam on the surface of the mucus, and the ascarides were alive and moving in the mucus itself, which probably hindered the oil from coming in contact with them and killing them.

Dr Heberden also observes, that mucus or slime is the proper nest of the ascarides, in which they live, and is perhaps the food by which they are nourished; and it is this mucus which preserves them unhurt, though surrounded with many other liquors, the immediate touch of which would be fatal. It is hard to satisfy ourselves by what instinct they find it out in the human body, and by what means they get at it; but it is observable in many other parts of nature, as well as here, that where there is a fit soil for the hatching and growth of animals and vegetables, nature has taken sufficient care that their seeds should find the way thither. Worms are said to have been found in the intestines of still-born infants. Purges, by lessening this slime, never fail to relieve the patient: and it is not unlikely, that the worms which are not forced away by this quickened motion of the intestines, may, for want of a proper quantity of it, languish, and at last die; for if the ascarides are taken out of their mucus, and exposed to the open air, they become motionless, and apparently die in a very short time. Dr Heberden supposes that the kind of purge made use of is of some consequence in the cure of all other worms as well as ascarides; the animals being always defended by the mucus from the immediate action of medicines; and that therefore those purges are the best which act briskly, and of which a repetition can be most easily borne. Purging waters are of this sort, and jalap especially for children; two or more grains of which, mixed with sugar, are most easily taken, and may be repeated daily.

From Dr Heberden's observations, we may easily see why it is so difficult to destroy these animals; and why anthelmintics, greatly celebrated for some kinds, are yet so far from being specifics in the disease. As the worms which reside in the cavities of the human body are never exposed to the air, by which all living creatures are invigorated, it is evident, that in themselves they must be the most tender and easily destructible creatures imaginable, and much less will be requisite to kill them than any of our common insects. The most pernicious substances to any of the common insects are oil, caustic fixed alkali, lime, and lime-water. The oil operates upon them by shutting up the pores of their bodies; the lime, lime-water, and caustic alkali, by dissolving their very substance. In the case of intestinal worms, however, the oil can have very little effect upon them, as they are defended from it by the moisture and mucus of the intestines; the like happens with lime-water: and therefore it is necessary that the medicine should be of such a nature as to destroy both mucus and insects together; for which purpose the caustic fixed alkali is at once safe and efficacious; nor is it probable that any case of worms whatever could resist the proper use of this medicine. A very large dose of any salt indeed will also destroy the mucus and destroy the worms; but it is apt to inflame and excoriate the stomach and intestines, and thus to produce worse distempers than that which it was intended to cure. Dr Heberden gives the following remarkable case of a patient cured of worms by enormous doses of common salt, after trying many other remedies in vain. In February 1757, the patient was seized with uncommon pains in his stomach, attended with nausea, vomiting, and constipation of bowels, and an almost total loss of sleep and appetite: He

He soon became much emaciated, and could neither stand nor walk upright; his belly grew small and hard, and closely retracted, insomuch that the sternum covered the navel, and the latter could scarce be discovered or felt by the finger: his urine was always milky, and soon deposited a thick white sediment; his excrements were very hard and lumpy, resembling those of sheep, only of a brown colour; nor had he ever a stool without some medicine or other to procure it. In this situation he continued four years; during which time he had been in an infirmary, attended by eminent physicians, but was dismissed as incurable. At last he was advised by a neighbour to drink salt and water, as he said he knew one cured by it who had for many years been afflicted with the same kind of pains in the belly and stomach. As his distemper was now almost insupportable, he willingly tried the experiment. Two pounds of common salt were dissolved in as little water as possible, all which he drank in less than an hour. Soon afterwards he found himself greatly oppressed at the stomach, grew extremely sick, and vomited violently; on the fourth straining he brought up about half a pint of small worms, part ascarides, and the rest resembling those worms which are called the *botts*, and frequently met with in the stomach of horses, but much smaller, and about the size of a grain of wheat. The salt soon began to operate downwards, and he had five or six very copious fetid stools, tinged with blood; and in them discharged near an equal quantity of the same kind of worms he had vomited. Being greatly fatigued with the violence of the operations, he fell into a calm sleep, which lasted two hours, during which he sweated profusely, and awoke much refreshed. Instead of his usual pains, he now only complained of a rawness and soreness of his gullet, stomach, and bowels, with an almost unquenchable thirst; to allay which, he drank large quantities of cold water, whey, butter-milk, or whatever he could get. The urine he now passed was small in quantity, and rendered with very great difficulty, being highly saturated with the salt, from whence arose a most troublesome dysuria and strangury. However these symptoms gradually abated by a free use of the liquors above mentioned; and on the third morning he was so well recovered, that he took two pounds more of salt, dissolved in the like quantity of water. The effects were nearly similar to the former; only that most of the worms were now burst, and came away with a considerable quantity of slime and mucus. The drought, strangury, &c. returned with their former violence, but soon yielded to the old treatment. He sweated very copiously for three days, slept easily, and by that time could extend his body freely: on the fifth day he left his bed, and, though very weak, could walk upright; his strength and appetite soon returned, and he became robust and well.

The anthelmintic medicines which have been recommended by one person or other, are in a manner innumerable; but the principal are,

1. *Quicksilver*. This is very efficacious against all kinds of worms, either taken in the form of calomel or corrosive sublimate. Even the crude metal boiled in water, and the water drunk, has been recommended as an almost certain cure. But this, it is evident, can receive no impregnation from the mercury. If, therefore, it have any effect, it must be from some foreign and accidental impregnation. In most instances there can be no objection to mercury, but only that it is not endowed with any attenuating quality whereby the mucus in which these insects reside can be dissolved. It therefore fails in many cases, though it will most certainly destroy worms where it can get at them.

2. *Powder of tin*. This was for some time celebrated as a specific, and indeed we may reasonably expect good effects from it; as by its weight and grittiness it rubs off the mucus and worms it contains from the coats of the intestinal canal, in which case they are easily evacuated by purgatives. In order to produce any considerable effects, it must be given in a large dose.

3. *Geoffræa inermis*, or *cabbage bark*. This remedy is used by the inhabitants of Jamaica. The first account of it which appeared in this country was published in the Physical and Literary Essays, vol. ii. by Mr Duguid surgeon in that island. He acquaints us, that the inhabitants of Jamaica, young and old, white and black, are much infested with worms, especially the long round sort; the reason of which, he thinks, is the quantity of sweet viscid vegetables which they eat. On dissecting a child of seven months old, who died of vomiting and convulsions, twelve large worms were found; one of them filled the *appendix vermiformis*, and three of them were entwisted in such a manner as to block up the *valvula Tulpii*, so that nothing could pass from the small to the great guts.—The cabbage bark, however, he tells us, is a safe and effectual remedy, and the most powerful vermifuge yet known; and that it it frequently brings away as many worms by stool as would fill a large hat. He owns that it has sometimes violent effects; but this he ascribes to the negroes who make the decoction (in which form the bark is used) too strong, and not to the remedy itself.

Mr Anderson, surgeon in Edinburgh, has also given an account of this bark and its operation, in a letter to Dr Duncan, published in the Edinburgh Medical Commentaries, volume iv. p. 84. From this account it appears, that there are two different kinds of cabbage bark; the one much paler than the other: the pale kind operates much more violently than the other. It often occasions loose stools, great nausea, and such like symptoms, attended with great uneasiness in the belly: in one or two instances it was suspected of inducing syncope. The darker coloured kind resembles the cassia lignea, though it is of a much coarser texture. This kind, Mr Anderson thinks, may be exhibited in any case where an anthelmintic is necessary; the dangerous symptoms might have followed either from the use of the first kind, or from an over-dose of the second. The usual method of preparing the medicine is by boiling two ounces and a half of the bark in two quarts of water to a pint and a half. Of this a tea-spoonful may be given at first in the morning, gradually increasing the quantity till we come to four or five table-spoonfuls in a day. When exhibited in this manner, Mr Anderson informs us, that he never saw it produce any violent symptoms, and has experienced the best effects from it as an anthelmintic. After the use of this decoction for eight or

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or nine mornings successively, a dose of jalap with calomel must be given, which seldom fails to bring away the worms, some dead, some alive. If at any time the decoction produce more than one or two loose stools, a few drops of liquid laudanum may be given; and, in general, Mr Anderson gave 15 or 20 drops of the spirit of lavender with each dose.

In a letter from Dr Rush, professor of chemistry at Philadelphia, to Dr Duncan of Edinburgh, the following account is given of another preparation of this medicine. "It has long (says he) been a complaint among physicians, that we have no *vermifuge* medicine which can be depended upon. Even calomel fails in many cases where there are the most pathognomonic signs of worms in the bowels. But this complaint, it is hoped, is now at an end. The physicians of Jamaica have lately found, that the *cabbage-bark*, as it is called in the West Indies, made into a syrup with brown sugar, is an infallible antidote to them. I have used above 30 pounds of it, and have never found it fail in one instance. The syrup is pleasant; it sometimes pukes, and always purges, the first or second time it is given."

The most accurate botanical description of the geoffrœa inermis, or the tree furnishing the worm bark, as it has often been called, is that which was published some years ago in the Philosophical Transactions by Dr Wright, formerly physician at Jamaica, now of Edinburgh, who also highly extolls this remedy as an anthelmintic.

Notwithstanding these encomiums, however, the cabbage bark has not come into general use in Britain. But diseases from *teretes*, or *lumbrici* as they are often called, the species of worm against which this bark is employed, much less frequently occur in Britain than in some other countries. When they do occur, in almost every instance they readily yield to more gentle and safe anthelmintics; and the worms may not only be expelled by calomel, but by the vegetable bitters; as the powder of the artemisia santonica, or the like.

4. *Couhage*, or *cow-itch*. This is the *Dolichos urens* or *pruriens* of Linnæus; and the principles on which it acts have been already explained under the article Dolichos. It is somewhat similar to the powder of tin, but bids fair for being more efficacious. It might at first appear to occur as objections to this medicine, that by the hairs of it entangling themselves with one another, calculi might be formed in the intestines, or obstructions equally bad; or if the sharp points or hooks with which it abounds were to adhere to the nervous coats of the intestines themselves, they might occasion a fatal irritation, which could not be removed by any means whatever. But from the experience of those who have employed it extensively in practice, it would appear that these objections are entirely theoretical: and that it may be employed with perfect safety. The spiculæ, gently scraped off from a single pod, and mixed with syrup or melasses, are taken for a dose in the morning fasting. This dose is repeated in this manner for two or three days without any sensible operation; but even a very slight purgative taken afterwards has been found to discharge an almost incredible quantity of worms. And according to Dr Bancroft, who has given a very particular account of its use in his Natural History of Guiana, it is one of the safest and most certain anthelmintics yet discovered; but as well as the bark of the *Geoffræa*, it has hitherto been very little used in Britain, probably from its not being necessary.

5. *Indian pink*. This plant, which is the *Spigelia marilandica* of Linnæus, is also an American plant, and was first recommended in the Edinburgh Physical and Literary Essays by Dr Garden of Charlestown in South Carolina. He is of opinion that a vomit ought always to precede the use of it; and informs us, that half a dram of it purges as briskly as the same quantity of rhubarb. At other times he has known it produce no effect on the belly though given in very large quantity: In such cases it becomes necessary to add a grain or two of sweet mercury, or some grains of rhubarb; but then it is less efficacious than when it proves purgative without addition. The use of it, however, in small doses, is by no means safe; as it frequently produces giddiness, dimness of sight, convulsions, &c. The addition of a purgative, indeed, prevents these effects; but at the same time, as already observed, it diminishes the virtue of the medicine. The doctor therefore recommends large doses, as from them he never knew any other effect than the medicine's proving emetic or violently cathartic. The dose is from 12 to 60 or 70 grains of the root in substance, or two, three, or four drams of the infusion, twice a-day. This medicine has also had its day, and is now very far from being considered as a specific.

The long round worms seem to be the most dangerous which infest the human body, as they often pierce through the stomach and intestines, and thus bring on a miserable death. The common symptoms of them are nausea, vomiting, looseness, fainting, slender intermitting pulse, itching of the nose, and epileptic fits. By the consumption of the chyle they produce hunger, paleness, weakness, costiveness, tumor of the abdomen, eructations, and rumbling of the intestines; but it is from the perforation of the intestines that the disease proves so frequently fatal. A child may be known to have worms from his cold temperament, paleness of the countenance, livid eyelids, hollow eyes, itching of the nose, voracity, startings, and grinding of the teeth, in sleep; and more especially by a very fetid breath. Very frequently, however, they are voided by the mouth and anus, in which case there is no room for doubt. In the Medical Commentaries, vol. ii. we have an account of the intestines being perforated by a worm, and yet the patient recovered. The patient was a woman troubled with an inflammation in the lower part of the abdomen. The pain was so violent, that for six days she slept none at all; the tumor then broke, discharged upwards of a pound of thin watery sanies, immediately after which the excrements followed. The next day she was extremely low; her pulse could scarcely be felt; the extremities were cold; and there was a considerable discharge from the wound, which had already begun to mortify. She got a decoction of cinchona with wine, which alleviated the symptoms; but in removing the mortified parts a worm was found among them six inches long, and as thick as an eagle's quill. By proper applications, the discharge of excrements ceased, and she recovered perfect health. She was sensible of no accident giving rise to the

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the inflammation; so that in all probability it arose entirely from the worm itself.

The *tænia*, or *tape-worm* as it is called, is one of those most difficult to be removed from the human body. It is of two kinds, *tænia solium* and *tænia lata*; for a description of which see the article Tænia.—The reason of its being so difficult to cure is, that though portions of it are apt to break off and be discharged, it is endowed with a power of reproduction, so that the patient is little or nothing better. The symptoms occasioned by it are not different from those above described. A specific against the *tænia lata* has been lately so much celebrated in France, that the king thought proper to purchase it from the proprietor (Madame Nouffer), and the account of it has been translated into English by Dr Simmons. The patients are required to observe no particular regimen till the day before they take the specific. That day they are to take nothing after dinner till about 7 o'clock; after which, they are to take the following soup: "Take a pint and a half of water, two or three ounces of good fresh butter, and two ounces of bread cut into thin slices: add to this salt enough to season it, and then boil it to the consistence of panada." About a quarter of an hour after this, they take a biscuit and a glass of white wine, either pure or mixed with water; or even water alone, if they have not been accustomed to wine. If the patient has not been to stool that day, (which, however, is not usual with patients in this way), the following clyster is to be injected. "Take a small quantity of the leaves of mallows, and boil them in a sufficient quantity of water, mixing with it a little salt, and when strained off add two ounces of olive oil." Next morning, about eight or nine hours after the supper above mentioned, the specific is to be taken. This is no other than two or three drams of the root of male fern, *polypodium filix mas* of Linnæus, gathered in autumn, and reduced to fine powder. It is to be taken in any distilled water, or in common water. This medicine is apt to occasion a nausea: to avoid which, Madame Nouffer allows her patients to chew any thing that is agreeable, but forbids any thing to be swallowed; or they may smell to vinegar, to check the sickness: but if, notwithstanding this, the specific be thrown up, a fresh dose must be swallowed as soon as the sickness is gone off, and then they must try to sleep. About two hours after this the following bolus is to be taken. "Take of the panacea of mercury 14 times sublimed, and select resin of scammony, each ten grains; of fresh and good gamboge, six or seven grains: reduce each of these substances separately into powder, and then mix them with some conserve into a bolus." This composition is to be swallowed at two different times, washing it down with one or two dishes of weak green-tea, after which the patient must walk about his chamber. When the bolus begins to operate, he is to take a dish of the same tea occasionally, until the worm be expelled; then, and not before, Madame Nouffer gives him broth or soup, and he is directed to dine as is usual after taking physic. After dinner he may either lie down or walk out, taking care to conduct himself discreetly, to eat but little supper, and to avoid every thing that is not of easy digestion.

The cure then is complete; but it is not always effected with the same quickness in every subject. He who has not kept down the whole bolus, or who is not sufficiently purged by it, ought to take, four hours after it, from two to eight drams of Epsom salt dissolved in boiling water. The dose of this salt may be varied according to the temperament and other circumstances of the patient.

If the worm should not come away in a bundle, but in the form of a thread (which particularly happens when the worm is involved in much tenacious mucus), the patient must continue to sit upon the close-stool without attempting to draw it away, drinking at the same time warm weak tea: sometimes this alone is not sufficient, and the patient is obliged to take another dose of purging salt, but without varying his position till the worm be wholly expelled.

It is unusual for patients who have kept down both the specific and purging dose, not to discharge the worm before dinner-time. This, however, sometimes happens when the dead worm remains in large bundles in the intestines, so that the fæces becoming more limpid towards the end of the purging, pass by it without drawing it with them. The patient may in this case eat his dinner; and it has been observed, that the food, joined to the use of a clyster, has brought about the expulsion of the worm.

Sometimes the worm is brought away by the action of the specific alone, before the patient has taken the purging bolus: when this happens, Madame Nouffer gives only two-thirds of it, or substitutes the salt in its stead.

Patients must not be alarmed by any sensation of heat or uneasiness they may feel during the action of the remedy, either before or after a copious evacuation, or just as they are about to void the worm. These sensations are transitory, and go off spontaneously, or by the assistance of the vapour of vinegar drawn in at the nose.

They who have vomited both the specific and bolus, or who have kept down only a part of them, sometimes do not void the worm that day. Madame Nouffer therefore directs them to take again that night the soup, the wine and biscuit; and if circumstances require it, the clyster. If the worm do not come away during the night, she gives them early the next morning another dose of the specific, and, two hours afterwards, six drams or an ounce of purging salt, repeating the whole process of the preceding day; excepting the bolus, which she suppresses.

She observes, that very hot weather diminishes in some degree the action of her remedy; she therefore prefers the month of September for administering it; but as she has not been always able to choose the season, and has been sometimes obliged to undertake the cure of patients in the hottest days of summer, she then gave her specific very early in the morning; and with this precaution she saw no difference in its effects.

On the day appointed for the trial of this medicine before the commissioners nominated by the king of France, it was exhibited to five different persons; but only one of them was certainly known to have the *tænia lata* by having discharged parts of it before. That person was cured; the second voided a potion of the *tænia solium*; the third some *ascarides*, with a part of the *tænia solium*; the fourth and fifth voided no worms; but

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but the last considered much of the viscid slime he voided to be worms in a dissolved state.

This trial was thought sufficient to ascertain the efficacy of the medicine, and further trials were made by those to whom the secret was communicated. The first voided two tænia, after much vomiting and 18 or 20 stools; the second had no vomiting, but was as violently purged, and discharged two worms; the third had 20 copious stools during the night, and discharged the worm in the morning; and the fifth was affected in much the same manner. Some others who were not relieved, were supposed not to have a tænia.

This specific, however, is not to be considered as a new discovery; the efficacy of fern in cases of tænia having been known long ago. Theophrastus prescribes its root, in doses of four drams, given in water sweetened with honey, as useful in expelling flat worms.—Dioscorides orders it in the same dose, and adds, that its effects are more certain when it is mixed with four oboli (40 grains) of scammony or black hellebore; he particularly requires that garlic should be taken before hand. Pliny, Galen, Oribasius, and Aëtius, ascribe this same virtue to fern; and are followed in this by Avicenna, and the other Arabian physicians. Dorstenius, Valerius Cordus, Dodonæus, Mathiolus, Dalechampius, who commented on Dioscorides, or copied him in many things, all mention the fern-root as a specific against the tænia. Sennertus, and Burnet after him, recommended in similar cases an infusion of this plant, or a dram of its powder, for young persons, and three drams for adults. Simon Paulus, quoted by Ray and Geoffroy, considers it as the most efficacious of all poisons against the flat worm, and as being the basis of all the secret remedies extolled by empirics in that disease. Andry prefers distilled fern-water to the root in powder, or he employs it only in the form of an opiate, or mixed with other substances.

These are not the only authors who have mentioned the tænia; many others have described this worm, the symptoms it excites, and the treatment proper to expel it. Almost all of them mention the fern-root, but at the same time they point out other remedies as possessing equal efficacy. Amongst these we find the bark of the root of the mulberry-tree, the juice of the *auricula murus*, the roots of *chamæleon niger*, ginger, zedoary; decoctions of mugwort, southernwood, wormwood, penny-royal, origanum, hyssop, and in general all bitter and aromatic plants, &c. Some of them direct the specific to be simply mixed and taken in wine or honey and water: others join to it the use of some purgative remedy, which they say adds to its efficacy. Oribasius, Sylvius, &c. distinguish the specific that kills the worm, from the purgative that evacuates it, and direct them to be given at different times. Sennertus gives a very satisfactory reason for adopting this method. If we give, says he, the purgative medicine and the specific at the same time, the latter will be hastily carried off before it can have exerted its powers on the worm: whereas, if we give the specific first, and thus weaken the worm, it will collect itself into a bundle, and, being brought away by means of the purge, the patient will be cured. The cure will be more speedy if the *primæ viæ* have been previously lubricated. These precautions are all of them essential to the success of the remedy, nor are they neglected by Madame Nouffer in her method of treatment. The panada and injection she prescribes the night before, to lubricate the intestines, and prepare the *primæ viæ*. The fern root, taken in the morning, kills and detaches the worm; of this the patients are sensible by the cessation of the pain in the stomach, and by the weight that is felt in the lower belly. The purgative bolus administered two hours after this, procures a complete evacuation; it is composed of substances that are at once purgative and vermifuge, and which, even when administered alone, by different physicians, sometimes succeeded in expelling the worm. If this purgative appear to be too strong, the reader is desired to recollect, that it produced no ill effects in either of the cases that came under the observation of the physicians appointed to make the trials; and that in one of those cases, by diminishing the dose, they evidently retarded the evacuations.—Regard however, they observe, is to be had both to the age and the temperament of the patient; and the treatment should always be directed by a prudent and experienced physician, who may know how to vary the proportions of the dose as circumstances may require. If the purgative be not of sufficient strength, the worm, after being detached by the specific, remains too long a time in the intestines, and becoming soon corrupted, is brought away only in detached portions: on the other hand, if the purgative be too strong, it occasions too much irritation, and evacuations that cannot fail to be inconvenient.

Madame Nouffer's long experience has taught her to distinguish all these circumstances with singular adroitness.

This method of cure is, as we have seen, copied in a great measure from the ancients: it may be possible to produce the same effects by varying the remedies; but the manner of applying them is by no means indifferent: we shall be always more certain of success if the intestines be previously evacuated, and if the specific be given some time before the purgative bolus. It is to this method that Madame Nouffer's constant success is attributed.

Her remedy has likewise some power over the *tænia solium*; but as the wings of this worm separate from each other more easily than those of the *tænia lata*, it is almost impossible for it to be expelled entire. It will be necessary therefore to repeat the treatment several times, till the patient cease to void any portions of worms. It must likewise be repeated, if, after the expulsion of one *tænia solium*, another should be generated in the intestinal canal. This last case is so rare, that it has been supposed that no person can have more than one of these worms; and for this reason it has been named *solitary worm*, which, being once removed, could never be renewed or replaced by a second: but experience has proved, that this notion is an ill-founded prejudice; and we know that sometimes these worms succeed each other, and that sometimes several of them exist together. Two living tæniæ have frequently been expelled from the same patient. Dr De Haen relates an instance of a woman who voided 18 tæniæ at once. In these cases the symptoms are usually more alarming; and the appetite becomes excessive, because these worms derive all their nourishment from the chyle. If too austere and ill-judged a regimen deprives orms. deprives them of this, they may be expected to attack even the membranes of the intestines themselves. This evil is to be avoided by eating frequently.

Such are the precautions indicated in this disease. The ordinary vermifuge remedies commonly procured only a palliative cure, perhaps because they were too often improperly administered. But the efficacy of the present remedy, in the opinion of the French physicians, seems to be sufficiently confirmed by experience. To the above account, however, it seems proper to subjoin the following observations by Dr Simmons.

"A Swiss physician, of the name of *Herrenschwand*, more than 20 years ago, acquired no little celebrity by distributing a composition of which he styled himself the *inventor*, and which was probably of the same nature as Madame Nouffer's. Several very eminent men, as Tronchin, Hovius, Bonnet, Cramer, and others, have written concerning the effects of this remedy. It seems that Dr Herrenschwand used to give a powder by way of preparation, the night before he administered his specific. Nothing could be said with certainty concerning the composition either of one or the other. The treatment was said sometimes to produce most violent effects, and to leave the patients in a valetudinary state. Dr De Haen was dissuaded by his friends from using it, because it disordered the patients too much. It will be readily conceived, now that we are acquainted with Madame Nouffer's method, that these effects were occasioned wholly by the purgative bolus. It is not strange, that resin of scammony or jalap, combined with *mercurius dulcis* and gamboge, all of them in strong doses, should in many subjects occasion the greatest disorders. It seems likely, however, that much of the success of the remedy depends on the use of a drastic purge. Some of the ancients who were acquainted with the virtues of the fern root, observed that its efficacy was increased by scammony. Resinous purges, especially when combined with mercury, have often been given with success in cases of *tænia*. Dr De Haen saw a worm of this sort five ells long expelled by the resin of jalap alone. Dr Gaubius knew a women who had taken a variety of anthelmintic remedies without any effect, though she had voided a portion of *tænia* an ell and a half long previous to the use of these medicines: but at length, after taking a purge of singular strength, she voided the worm entire. Many other instances of the same kind are to be met with in authors. Other remedies have occasionally been given with success. In Sweden, it has been a practice to drink several gallons of cold water, and then to take some drastic purge. Boerhaave says, that he himself saw a *tænia* measuring 300 ells expelled from a Russian by means of the sulphate of iron.

From some late accounts, there is reason to believe that Dr Herrenschwand's remedy for *tænia* does not so exactly agree with that of Madame Nouffer as Dr Simmons seems to imagine. According to the account given us by a gentleman who had his information from Dr Herrenschwand himself, it consists entirely of gamboge and fixed vegetable alkali.

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Of POISONS.

Of many poisons we have already treated, but there are some of which nothing has hitherto been said. Among the most fatal of these are the bites and stings of serpents, scorpions, &c. According to Dr Mead, the symptoms which follow the bite of a viper are, an acute pain in the place wounded, with a swelling, at first red, but afterwards livid, which by degrees spreads farther to the neighbouring parts; with great faintness, and a quick, low, and sometimes interrupted pulse; great sickness at stomach, with bilious convulsive vomitings, cold sweats, and sometimes pains about the navel. Frequently a sanious liquor runs from the small wound, and little pustules are raised about it: the colour of the whole skin in less than an hour is changed yellow, as if the patient had the jaundice. These symptoms are very frequently followed by death, especially if the climate be hot, and the animal of a large size. This is not, however, the case with all kinds of serpents. Some, we are assured, kill by a fatal sleep; others are said to produce an universal hæmorrhage and dissolution of the blood; and others an unquenchable thirst. But of all the species of serpents hitherto known, there is none whose bite is more expeditiously fatal than that of the rattlesnake. Dr Mead tells us, that the bite of a large serpent of this kind killed a dog in a quarter of a minute; and to the human species they are almost equally fatal. Of this serpent it is said, that the bite makes the person's skin become spotted all over like the skin of the serpent; and that it has such a motion as if there were innumerable living serpents below it. But this is probably nothing more than a dissolution of the blood, by which the skin becomes spotted as in petechial fevers; at the same time that the muscles may be convulsed as in the distemper called *hieranosos*, which was formerly thought to be the effect of evil spirits: but it is even not improbable that observers have been somewhat aided by fancy and superstition when they thought that they detected such appearances.

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It has justly appeared surprising to philosophers, how such an inconsiderable quantity of matter as the poison emitted by a viper at the time of biting should produce such violent effects. But all inquiries into this matter must necessarily be uncertain; neither can they contribute any thing towards the cure. It is certain that the poison produces a gangrenous disposition of the part itself, and likewise seemingly of the rest of the body; and that the original quantity of poison continues some time before it exerts all its power on the patient, as it is known that removing part of the poisonous matter by suction will alleviate the symptoms. The indications of cure then are three: 1. To remove the poisonous matter from the body: Or, 2. If this cannot be done, to change its destructive nature by some powerful and penetrating application to the wound: And, 3. To counteract the effects of that portion already received into the system.

The poisonons matter can only be removed from the body by sucking the wound either by the mouth, or by means of a cupping glass; but the former is probably the more efficacious, as the saliva will in some measure dilute and perhaps obtund the poison. Dr Mead directs the person who sucks the wound to hold warm oil in his mouth, to prevent inflammation of the lips and tongue: but as bites of this kind are most likely to happen in the fields, and at a distance from houses, the want of oil ought by no means to retard the operation, as the delay of a few minutes might prove

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prove of the most fatal consequence; and it appears from Dr Mead's experiments, that the taking the poison of a viper into the mouth undiluted, is attended with no worse consequences than that of raising a slight inflammation. A quick excision of the part might also be of very great service.

The only way of answering the second indication is, by destroying the poisoned part by a red-hot iron, or the application of alkaline salts, which have the power of immediately altering the texture of all animal substances to which they are applied, provided they are not covered by the skin; and as long as the poison is not totally absorbed into the system, these must certainly be of use.

To answer the third indication, Dr Mead recommends a vomit of ipecacuanha, encouraged in the working with oil and warm water. The good effects of this, he says, are owing to the shake which it gives to the nerves, whereby the irregular spasms into which their whole system might be drawn are prevented. After this the patient must go to bed, and a sweat must be procured by cordial medicines; by which the remaining effects of the poison will be carried off.

It has been confidently asserted by many, that the American Indians are possessed of some specific remedy by which they can easily cure the bite of a rattlesnake. But Mr Catesby, who must have had many opportunities of knowing this, positively denies that they have any such medicine. They make applications indeed, and sometimes the patient recovers; but these recoveries he ascribes to the strength of nature overcoming the poison, more than to the remedies made use of. He says, they are very acute in their prognostics whether a person that is bit will die or not; and when they happen to receive a bite in certain parts of the body, when the teeth of the animal enter a large vein, for instance, they quietly resign themselves to their fate, without attempting any thing for their own relief. Indeed, so violent and quick is the operation of this poison, that unless the antidote be instantly applied, the person will die before he can get to a house. It would seem therefore eligible for those who are in danger of such bites, to carry along with them some strong alkaline ley, or dry alkaline salt, or both, which could be instantly clapt on the wound, and by its dissolving power would destroy both the poison and the infected parts. Strong cordials also, such as ardent spirits, volatile alkali, &c. might possibly excite the languid powers of nature, and enable her to expel the enemy, which would otherwise prove too powerful. This seems to be somewhat confirmed from the account we have in the Philosophical Transactions of a gentleman bit by a rattlesnake, who was more relieved by a poultice of vinegar and vine-ashes put to his wound than any thing else. The vine-ashes being of an alkaline nature, must have saturated the vinegar, so that no part of the cure could be attributed to it: on the other hand, the ashes themselves could not have been saturated by the small quantity of acid necessary to form them into a poultice; of consequence they must have operated by their alkaline quality.—Soap ley, therefore, or very strong salt of tartar, may reasonably be thought to be the best external application, not only for the bites of vipers, but of every venomous creature; and in fact we find *dry salt* universally recommended both in the bites of serpents and of mad dogs. Dr Mead recommends the fat of vipers immediately rubbed into the wound; but owns that it is not safe to trust to this remedy alone.

Some years ago the volatile alkali was strongly recommended by M. Sage of the French academy, as a powerful remedy against the bite of a viper: and, by a letter from a gentleman in Bengal to Dr Wright, it would appear that this article, under the form of the *eau de luce*, which is very little if any thing different from the *spiritus ammoniæ succinatus* of the London Pharmacopœia, has been employed with very great success against this affection in the East Indies: but from the trials made with it by the abbé Fontana, published in his Treatise on the Poison of the Viper, it would appear that it by no means answered his expectation; and the efficacy of this, as well as of the snake pills mentioned under the article HYDROPHOBIA, still requires to be confirmed by further experience.

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This is a distemper not very common, but it has been observed by the ancient physicians, and is described by Hippocrates under the name of *morbus niger*. It shows itself by a vomiting and purging of black tar-like matter, which Hippocrates, Boerhaave, and Van Swieten, supposed to be occasioned by atra bilis. But Dr Home, in his Clinical Experiments, endeavours to shew that it is owing to an effusion of blood from the meseraic vessels, which, by its stagnation and corruption, assumes that strange appearance. The disease, he says, frequently follows hæmorrhage; and those of a scorbutic habit are most subject to it. It is an acute disease, and terminates soon; yet it is not attended with any great degree of fever. In one of Dr Home's patients the crisis happened on the eighth day by diarrhœa; in another, on the 14th, by sweat and urine; and a third had no evident critical evacuation.

As to the cure, Dr Home observes, that bleeding is always necessary where the pulse can bear it; nor are we to be deterred from it by a little weakness of the pulse, more than in the enteritis. Emetics are hurtful, but purgatives are useful. But the most powerful medicine for checking this hæmorrhage is the sulphuric acid: and, that this might be given in greater quantity, he mixed it with mucilage of gum arabic; by which means he was enabled to give double the quantity he could otherwise have done. The cold bath was tried in one instance, but he could not determine whether it was of any service or not. The cure was completed by exercise and cinchona.

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Diseases of Childr[en]

Dr Buchan observes, that from the annual registers of the dead, it appears that about one half of the children born in Great Britain die under twelve years of age; and this very great mortality he attributes in a great measure to wrong management. The particulars of this wrong management enumerated by him are,

1. Mothers not suckling their own children. This, he owns, it is sometimes impossible for them to do; but

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but where it can be done, he affirms that it ought never to be omitted. This, he says, would prevent the unnatural custom of mothers leaving their own children to suckle those of others; on which he passes a most severe censure, and indeed scarce any censure can be severe enough upon such inhumanity. Dr Buchan informs us, "He is sure he speaks within bounds, when he says not one in an hundred of these children live who are thus abandoned by their mothers." For this reason he adds, that no mother should be allowed to suckle another's child till her own be fit to be weaned. A regulation of this kind would save many lives among the poorer sort, and would do no harm to the rich; as most women who make good nurses are able to suckle two children in succession upon the same milk.

2. Another source of the diseases of children is the unhealthiness of parents: and our author insists that no person who labours under an incurable malady ought to marry.

3. The manner of clothing children tends to produce diseases. All that is necessary here, he says, is to wrap the child in a soft loose covering; and the softness of every part of the infant's body sufficiently shows the injury which must necessarily ensue by pursuing a contrary method.

4. A new-born infant, instead of being treated with syrups, oils, &c. ought to be allowed to suck the mother's milk almost as soon as it comes into the world. He condemns the practice of giving wines and spirituous liquors along with the food soon after birth; and says, that if the mother or nurse has a sufficient quantity of milk, the child will need little or no other food before the third or fourth month. But to this it may reasonably be objected, not only that the nursing would thus be very severe on the mother; but if the child be left thus long without other food, it will not easily relish that food for some time, and its stomach is apt to be easily hurt by a slight change of diet after it has been long accustomed to one thing. The human species are unquestionably fitted by nature for a mixed aliment, both from the vegetable and animal kingdom. And the analogy of other animals belonging to the class of mammalia for whom milk is equally provided at the earliest periods of life, would lead us to the conclusion, that mixed aliment is well fitted for the human species even in the earliest periods of infancy. The lamb is no sooner dropt than, by natural instinct, it crops the grass as well as it sucks its mother. And the stomach in the human species, immediately after birth, can digest other food as well as milk. Neither can it be shown, that the strongest and most healthy infants are those which get no other food but the mother's milk during the first months of their life. In fact, children are evidently of a weak and lax habit of body, so that many of their diseases must arise from that cause; all directions which indiscriminately advise an antiphlogistic regimen for infants as soon as they come into the world, must of necessity be wrong. Many instances in fact might be brought to show, that by the preposterous method of starving infants, and at the same time treating them with vomits and purges, they are often hurried out of the world. Animal food indeed, particularly under the form of broths, is excessively agreeable to children, and they ought to be indulged with it in moderation. This will prove a much better remedy for those acidities with which children are often troubled, than magnesia alba, crabs eyes, or other absorbents, which have the most pernicious effects on the stomachs of these tender creatures, and pall the appetite to a surprising degree. The natural appetites of children are indeed the best rule by which we can judge of what is proper or improper for them. They must no doubt be regulated as to the quantity; but we may be assured that what a child is very fond of will not hurt it, if taken in moderation. When children are sick, they refuse every thing but the breast; and if their distemper be very severe, they will refuse it also, and in this case they ought not to be pressed to take food of any kind; but when the sickness goes off, their appetite also returns, and they will require the usual quantity of food.

According to Dr Armstrong, *inward fits*, as they are called, are in general the first complaint that appears in children; and as far as he has observed, most, if not all infants, during the first months, are more or less liable to them. The symptoms are these: The child appears as if it was asleep, only the eyelids are not quite closed; and if you observe them narrowly, you will see the eyes frequently twinkle, with the white of them turned up. There is a kind of tremulous motion in the muscles of the face and lips, which produces something like a simper or a smile, and sometimes almost the appearance of a laugh. As the disorder increases, the infant's breath seems now and then to stop for a little; the nose becomes pinched; there is a pale circle about the eyes and mouth, which sometimes changes to livid, and comes and goes by turns; the child starts, especially if you attempt to stir it though ever so gently, or if you make any noise near it. Thus disturbed, it sighs, or breaks wind, which gives relief for a little; but presently it relapses into the dozing. Sometimes it struggles hard before it can break wind, and seems as if falling into convulsions; but a violent burst of wind from the stomach, or vomiting, or a loud fit of crying, sets all to rights again. As the child increases in strength, these fits are the more apt to go off spontaneously and by degrees; but in case they do not, and if there is nothing done to remove them, they either degenerate into an almost constant drowsiness, (which is succeeded by a fever and the thrush), or else they terminate in vomitings, sour, curdled, or green stools, the watery gripes, and convulsions. The thrush indeed very often terminates in these last symptoms. As these complaints naturally run into one another, or succeed one another, they may be considered, in a manner, as only different stages of the same disease, and which derive their origin from the same cause. Thus, the inward fits may be looked upon as the first stage of the disorder; the fever, and thrush (when it happens), as the second; the vomitings, sour, curdled, green or watery stools, as the third; and convulsions as the last.

As to the cause of these complaints, he observes, that in infants the glandular secretions, which are all more or less glutinous, are much more copious than in adults. During the time of sucking, the glands of the mouth and fauces being squeezed by the contraction of the muscles, pour forth their contents plentifully; which afterwards mixing with the mucus of the gullet and

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and stomach, renders the milk of a slimy consistence, by which means it is not so readily absorbed into the lacteals; and as in most infants there is too great an acidity in the stomach, the milk is thereby curdled, which adds to the load; hence sickness and spasms, which, being communicated by sympathy to the nerves of the gullet and fauces produce the convulsive motions above described, which go commonly by the name of *inward fits*. The air, likewise, which is drawn in during suction mixing with the milk, &c. in the stomach, perhaps contributes towards increasing the spasms above mentioned. Dr Armstrong is the more induced to attribute these fits to the causes now assigned, that they always appear immediately after sucking or feeding; especially if the child has been long at the breast, or fed heartily, and has been laid down to sleep without having first broken wind. Another reason is, that nothing relieves them so soon as belching or vomiting; and the milk or food they throw up is generally either curdled, or mixed with a large quantity of heavy phlegm. If they be not relieved by belching or vomiting, the fits sometimes continue a good while, and gradually abate, according as the contents of the stomach are pushed into the intestines; and as soon as the former is pretty well emptied, the child is waked by hunger, cries, and wants the breast; he sucks, and the same process is repeated.—Thus, some children for the first weeks are kept almost always in a doze, or seemingly so; especially if the nurses, either through laziness or want of skill, do not take care to rouse them when they perceive that it is not a right sleep, and keep them awake at proper intervals. This dozing is reckoned a bad sign amongst experienced nurses; who look upon it as a forerunner of the thrush, as indeed it often is; and therefore, when it happens, we ought to be upon our guard to use the necessary precautions for preventing that disorder.

For these disorders, the only remedy recommended by Dr Armstrong is antimonial wine, given in a few drops according to the age of the infant. By this means the superabundant mucus will no doubt be evacuated; but at the same time we must remember, that this evacuation can only *palliate*, and not cure the disease. This can only be effected by tonics; and, when from inwards fits and other symptoms it appears that the tone of the stomach is very weak, a decoction of cinchona, made into a syrup, will readily be taken by infants, and may be safely exhibited from the very day they come into the world, or as soon as their bowels are emptied of the meconium by the mother's milk or any other means.

Dr Clarke observes, that *fractures* of the *limbs* and *compressions* of the *brain*, often happen in difficult labours; and that the latter are often followed by convulsions soon after delivery. In these cases, he says, it will be advisable to let the navel-string bleed two or three spoonfuls before it be tied. Thus the oppression of the brain will be relieved, and the disagreeable consequences just mentioned will be prevented. But if this has been neglected, and fits have actually come on, we must endeavour to make a revulsion by all the means in our power; as by opening the jugular vein, procuring an immediate discharge of the urine and meconium, and applying small blisters to the back, legs, or behind the ears. The semicupium, too, would seem to be useful in this case, by driving the oppressive load of fluids from the head and upper parts.

It sometimes happens after a tedious labour, that the child is so faint and weak as to discover little or no signs of life. In such a case, after the usual cleansing, the body should be immediately wrapped in warm flannel, and briskly tossed about in the nurse's arms, in order, if possible, to excite the languid circulation. If this fail, the breast and temples may be rubbed with brandy or other spirits; or the child may be provoked to cry, by whipping, or other stimulating methods, as the application of onion, or salt and spirit of hartshorn, to the mouth and nostrils. But after all these expedients have been tried in vain, and the recovery of the child absolutely despaired of, it has sometimes been happily revived by introducing a short catheter or blowpipe into the mouth, and gently blowing into the lungs at different intervals. Such children, however, are apt to remain weak for a considerable time, so that it is often no easy matter to rear them; and therefore particular care and tenderness will be required in their management, that nothing may be omitted which can contribute either to their preservation or the improvement of their strength and vigour.

All the disorders which arise from a *retention* of the *meconium*, such as the *red gum*, may easily be removed by the use of gentle laxatives; but the great source of mortality among children is the *breeding* of their *teeth*. The usual symptoms produced by this are fretting; restlessness; frequent and sudden startings, especially in sleep; costiveness; and sometimes a violent diarrhœa, fever, or convulsions. In general, those children breed their teeth with the greatest ease, who have a moderate laxity of the bowels, or a plentiful flow of saliva during that time.

In mild cases, we need only, when necessary, endeavour to promote the means by which nature is observed to carry on the business of dentition in the easiest manner. For this purpose, if a costiveness be threatened, it must be prevented, and the body kept always gently open; the gums should be relaxed by rubbing them frequently with sweet oils, or other softening remedies of that kind, which will greatly diminish the tension and pain. At the same time, as children about this period are generally disposed to chew whatever they get into their hands, they ought never to be without something that will yield a little to the pressure of their gums, as a crust of bread, a wax candle, a bit of liquorice root, or such like; for the repeated muscular action, occasioned by the constant biting and gnawing at such a substance, will increase the discharge from the salivary glands, while the gums will be so forcibly pressed against the advancing teeth, as to make them break out much sooner, and with less uneasiness, than would otherwise happen. Some likewise recommend a slice of the rind of fresh bacon, as a proper masticatory for the child, in order to bring moisture into its mouth, and facilitate the eruption of the teeth by exercising the gums. If these means, however, prove ineffectual, and bad symptoms begin to appear, the patient will often be relieved immediately by cutting the inflamed gum down to the tooth, where a small white point shows the latter to be coming forward. When the pulse is quick, the skin hot and dry, and the child of a sufficient age and strength, emptying the vessels by bleeding,

ing, especially at the jugular, will frequently be necessary here, as well as in all other inflammatory cases; and the belly should be opened from time to time by emollient, oily, or mucilaginous clysters. But, on the contrary, if the child be low, sunk, and much weakened, repeated doses of the spirit of hartshorn, and the like reviving medicines, ought to be prescribed. Blisters applied to the back, or behind the ears, will often be proper in both cases. A prudent administration of opiates, when their use is not forbid by costiveness or otherwise, is sometimes of great service in difficult teething, as, by mitigating pain, they have a tendency to prevent its bad effects, such as a fever, convulsions, or other violent symptoms; and often they are absolutely necessary, along with the testaceous powders, for checking an immoderate diarrhœa.

When cathartics are necessary, if the child seems too tender and weak to bear their immediate operation, they should be given to the nurse; in which case they will communicate so much of their active powers to the milk as will be sufficient to purge the infant. This at least certainly holds with regard to some cathartics; such, for example, as the infusion of senna, particularly if a very weak infusion be employed, and not used to such an extent as to operate as a purgative to the nurse.

As most young children, if in health, naturally sleep much, and pretty soundly, we may always be apt to suspect that something is amiss when they begin to be subject to *watching* and *frights;* symptoms which seldom or never occur but either in consequence of some present disorder not perceived, or as the certain forerunners of an approaching indisposition. We should immediately, therefore, endeavour to find out the cause of watchfulness, that we may use every possible means to remove or prevent it; otherwise the want of natural rest, which is so very prejudicial to persons of all ages, will soon reduce the infant to a low and emaciated state, which may be followed by a hectic fever, diarrhœa, and all the other consequences of weakness. These symptoms, being always the effects of irritation and pain, may proceed, in very young infants, from crudities or other affections of the *primæ viæ* producing flatulencies or gripes; about the sixth or seventh month, they may be owing to that uneasiness which commonly accompanies the breeding of the teeth; and after a child is weaned, and begins to use a different kind of food, worms become frequently an additional cause of watchings and disturbed sleep. Hence, to give the necessary relief on these occasions, the original complaint must first be ascertained from the child's age and other concomitant circumstances, and afterwards treated according to the nature of the case. Women and nurses are too apt to have recourse to opiates in the watchings of children, especially when their own rest happens to be much disturbed by their continual noise and clamour. But this practice is often prejudicial, and never ought to have place when the belly is in the least obstructed.

There is no complaint more frequent among children than that of worms, the general symptoms of which have been already enumerated; but it must be observed, that all the symptoms commonly attributed to worms, may be produced by a foulness of the bowels. Hence practitioners ought never to rest satisfied with administering to their patients such medicines as are possessed only of an anthelmintic quality, but to join them with those which are particularly adapted for cleansing the *primæ viæ;* as it is uncertain whether a foulness of the bowels may not be the cause of all the complaints. This practice is still the more advisable, on account of viscid humours in the intestines affording lodgement to the ova of worms; which, without the convenience of such a receptacle, would be more speedily discharged from the body.

The difficulty of curing what is called a *worm fever*, arises, according to Dr Musgrave, from its being frequently attributed to worms, when the cause of the disorder is of a quite different nature. He does not mean to deny that worms do sometimes abound in the human body, nor that the irritation caused by them does sometimes produce a fever; but he apprehends these cases to be much more uncommon than is generally imagined, and that great mischief is done by treating some of the disorders of children as worm cases, which are really not so. Dr Hunter is of the same opinion on this point. He has, we are told, dissected great numbers of children who have been supposed to die of worm fevers, and whose complaints were of course treated as proceeding from worms, in whom, however, there appeared, upon dissection, to be not only no worms, but evident proofs of the disorder's having been of a very different nature.

The *spurious worm fever*, as Dr Musgrave terms it, has, in all the instances he has seen of it, arisen evidently from the children having been indulged with too great quantities of fruit. Every sort of fruit eaten in excess will probably produce it; but an immoderate use of cherries seems to be the most common cause of it. The approach of this disorder has a different appearance, according as it arises from a habit of eating fruit in rather too large quantities, or from an excessive quantity eaten at one time. In the former case, the patient gradually grows weak and languid: his colour becomes pale and livid; his belly swells and grows hard; his appetite and digestion are destroyed; his nights grow restless, or at least his sleep is much disturbed with startings, and then the fever soon follows, in the progress of which, the patient grows comatose, and at times convulsed; in which state, when it takes place to a high degree, he often dies. The pulse at the wrist, though quick, is never strong or hard; the carotids, however, beat with great violence, and elevate the skin so as to be distinctly seen at a distance. The heat is at times considerable, especially in the trunk; though at other times, when the brain is much oppressed, it is little more than natural. It is sometimes accompanied by a violent pain of the epigastric region, though more commonly the pain is slight, and terminates in a coma; some degree of pain, however, seems to be inseparable from it, so as clearly to distinguish this disorder from other comatose affections.

When a large quantity of fruit has been eaten at once, the attack of the disorder is instantaneous, and its progress rapid; the patient often passing, in the space of a few hours, from apparently perfect health, to a stupid, comatose, and almost dying state. The symptoms of the fever, when formed, are in both cases nearly the same; except that, in this latter sort, a little purulent matter is sometimes discharged, both by vomit

Diseases of Children.

mit and stool, from the very first day. The stools, in both cases, exhibit sometimes a kind of curd resembling curdled milk, at other times a floating substance is observed in them; and sometimes a number of little threads and pellicles, and now and then a single worm.

Strong purgatives, or purges frequently repeated, in this disorder, are greatly condemned by Dr Armstrong, as they in general not only aggravate the symptoms already present, but are sometimes the origin of convulsions. Bloodletting is not to be thought of in any stage of the disorder.

Although frequent purging, however, be not recommended, yet a single vomit and purge are advised in the beginning of the disorder, with a view to evacuate such indigested matter and mucus as happens to remain in the stomach and bowels. These having operated properly, there is seldom occasion for repeating them; and it is sufficient, if the body be costive, to throw up, every second or third day, a clyster, composed of some grains of aloes, dissolved in five or six ounces of infusion of chamomile.

The principal part of the cure, however, depends upon external applications to the bowels and stomach; and as the cause of the disorder is of a cold nature, the applications must be warm, cordial, and invigorating; and their action must be promoted by constant actual heat.

When any nervous symptoms come on, or remain after the disorder is abated, they are easily removed by giving a pill with a grain or two of asafœtida once or twice a-day.

The diagnostics of worms are very uncertain; but, even in real worm cases, the treatment above recommended would, it is imagined, be much more efficacious than the practice commonly had recourse to. As worms either find the constitution weakly, or very soon make it so, the frequent repetition of purges, particularly mercurials, cannot but have a pernicious effect. Bear's-foot is still more exceptionable, being in truth to be ranked rather among poisons than medicines. Worm seed and bitters are too offensive to the palate and stomach to be long persisted in, though sometimes very useful. The powder of coralline creates disgust by its quantity; and the infusion of pink root is well known to occasion now and then vertiginous complaints and fits.

Fomenting the belly night and morning with a strong decoction of rue and wormwood, is much recommended. It is a perfectly fafe remedy, and, by invigorating the bowels, may therefore have some influence in rendering them capable of expelling such worms as they happen to contain. After the fomentation, it is advised to anoint the belly with a liniment, composed of one part of essential oil of rue, and two parts of a decoction of rue in sweet oil. It is, however, a matter of great doubt whether these external applications, in consequence of the articles with which they are impregnated, exert any influence on the worms themselves.

The diet of children disposed to worms should be warm and nourishing, consisting in part at least of animal food, which is not the worse for being a little seasoned. Their drink may be any kind of beer that is well hopped, with now and then a small draught of porter or negus. A total abstinence from butter is not so necessary, perhaps, as is generally imagined. Poor cheese must by all means be avoided, but such as is rich and pungent, in a moderate quantity, is particularly serviceable. In the spurious worm fever, the patient should be supported occasionally by small quantities of broth; and, at the close of it, when the appetite returns, the first food given should be of the kinds above recommended.

The diet here recommended will, perhaps, be thought extraordinary, as the general idea is at present, that, in the management of children, nothing is so much to be avoided as repletion and rich food. It is no doubt an error to feed children too well, or to indulge them with wine and rich sauces; but it is equally an error to confine them to too strict or too poor a diet, which weakens their digestion, and renders them much more subject to disorders of every kind, but particularly to disorders of the bowels. In regard to the spurious worm fever, if it be true that acid fruits too plentifully eaten are the general cause of it, it follows as a consequence, that a warm nutritious diet, moderately used, will most effectually counteract the mischief, and soonest restore the natural powers of the stomach. Besides, if the disorder does not readily yield to the methods here directed, as there are many examples of its terminating by an inflammation and suppuration of the navel, it is highly adviseable to keep this probability in view, and, by a moderate allowance of animal food, to support those powers of nature, from which only such a happy crisis is to be expected.

Besides these, many other diseases might here be mentioned, which, if not peculiar to infants, are at least peculiarly modified by the infant state. But into details respecting these we cannot propose to enter. It is sufficient to say, that due regard being paid to age and constitution, the cure is to be conducted on the same general principles as in the adult state.

Medical Jurisprudence.

MEDICAL JURISPRUDENCE. 41

During the progress of science in Europe this subject has not been altogether neglected. But we may safely venture to assert, that even from many enlightened governments it has hitherto claimed much less attention than its importance merits. At the British universities this has been too much the case. It is indeed true, that for near 20 years a few lectures on this subject have been delivered at the university of Edinburgh, by the professor of the institutions of medicine. But he could by no means consider the subject on that extensive scale which its importance merited. And he had often expressed his regret, that, as in several of the foreign universities, a professorship had not been instituted for the express purpose of giving a course of lectures on medical jurisprudence. That defect, however, in medical education at Edinburgh is now supplied. When that able and upright statesman Lord Grenville, to whom every thing that regarded the laws of his country was an object of peculiar attention, was at the head of his majesty's councils, a regius professorship of juridical and political medicine was established in the university of Edinburgh by a royal warrant. And

And there is every reason to hope, that the appointment will be attended with many effects highly beneficial to the nation.

A short view of the extent and importance of this subject will, we presume, not be unacceptable to the intelligent reader.

Whatever aid the science of medicine can contribute towards the good of the state, and the execution of its laws, has been by the Germans denominated State Medicine; a new, but not improper, appellation, for that branch of knowledge which many writers have termed Medical Jurisprudence.

It comprehends both medical police and juridical medicine. The former consists of the medical precepts which may be of use to the legislature or to the magistracy. The latter is the aggregate of all the information, afforded by the different branches of medicine, which is necessary for elucidating doubtful questions in courts of law.

Although there are some traces of juridical medicine in the Justinian code; such as determining the real period of birth, with a view to prevent the imposition of spurious children: it properly originated with the code of laws enacted by the emperor Charles V. under the name of *Constitutio criminalis Carolina;* in which it is ordained, that the opinions of physicians should be taken, with regard to the danger of wounds, child-murder, murder, poisoning, procured abortion, concealed pregnancy, &c. These directions, and the impossibility which was found of determinating many questions by simply legal means, induced some legislators to enjoin, that all tribunals and judges should procure from sworn physicians, appointed to this office, their opinions concerning all the subjects to be mentioned hereafter.

Since that time, it has been treated systematically by many learned men; such as Fortunatus Fidelis, Zacchias, Alberti, Hebenstreit, Haller, Ludwig, Plenck; and lastly, in the most masterly manner, by Metzger. Numberless dissertations have been written on all its parts; and among those who contributed to its advancement, we may reckon Ambrose Parry, Bohn, Butener, Morgagni, Camper, and Gruner. Collections of cases, illustrating its principles, have been made by Amman, Daniel, Bucholz, Pyl, Scherf and Metzger. These are only a few of the principal writers who have attended to this science: to enumerate more would be unnecessary.

From its very nature, it is evident how necessary a knowledge of this science must be to every medical practitioner, who is liable to be called upon to illustrate any question comprehended under it before a court of justice. On his answers, the fate of the accused person must often depend; both judge and jury regulating their decision by his opinion. On the other hand, while he is delivering his sentiments, his own reputation is before the bar of the public. The acuteness of the gentlemen of the law is universally acknowledged; the versatility of their genius, and the quickness of their apprehension, are rendered almost inconceivable, by constant exercise. It is their duty to make every possible exertion for the interest of their client, and they seldom leave unnoticed any inaccurate or contradictory evidence. How cautious must, then, a medical practitioner be, when examined before such men, when it is their duty to expose his errors, and magnify his uncertainties, till his evidence seem contradictory and absurd? How often must he expose himself to such severe criticism, if he be not master of the subject on which he is giving evidence, and have not arranged his thoughts on it according to just principles? On the other hand, he may deserve and gain much credit, by so public a display of judgment and professional knowledge.

Some acquaintance with this part of medical science must be useful at least, and sometimes necessary, to judges and lawyers. They will thus be enabled to estimate how much they may depend on the opinion of any physician, and will know how to direct their questions, so as to arrive at the truth, and avoid being misled by his partiality or favourite opinions. To the lawyer who conducts the defence of an accused person, in a criminal case, it is almost indispensable; without it, he cannot do justice to the cause of his client.

Before criminal courts, the questions which occur most generally are, respecting

1. The cause of death, as ascertained from the examination of the body.
2. The sufficiency of the supposed cause to have produced death.
3. Probable event of wounds, contusions, &c.
4. The importance of the part injured.
5. Supposed child-murder; whether still-born or not.
6. Whether death accidental or intended.
7. Abortion; its having occurred.
8. Spontaneously, from habit; accidentally, from external violence or passions of the mind; or intentionally, from the introduction of a sharp instrument, use of certain drugs, &c.
9. Rape; its being attempted or consummated; recent or previous defloration.
10. The responsibility of the accused for his actions.

Before civil courts the questions generally regard,

1. The state of mind; madness, melancholy, idiotism.
2. Pregnancy; concealed, pretended.
3. Parturition; concealed, pretended, retarded, premature.
4. The first-born of twins.
5. Diseases; concealed, pretended, imputed.
6. Age and duration of life.

Before consistorial courts, the subjects investigated are,

1. Impotence; general, relative, curable, incurable.
2. Sterility; curable, relatively incurable, absolutely incurable.
3. Uncertainty of sex; hermaphrodites.
4. Diseases preventing cohabitation; venereal disease, leprosy, &c.

MEDICAL POLICE.

Of incomparably greater consequence, and more widely extended influence, is the second division of this subject. It regards not merely the welfare of individuals, but the prosperity and security of nations. It is perhaps the most important branch of general police; for its influence is not confined to those whom accidental circumstances bring within its sphere, but extends over the whole population of the state.

Many

Medical Police.

Many of its principles have been long acknowledged, and considered as necessary consequences of medical and political truths; and some few of them have acquired the authority of laws. But it was reserved for the philanthropic Frank, to collect the whole into one vast and beneficent system, and to separate it from juridical medicine; in the old systems of which, it was neglected, or mentioned only in a few short paragraphs. His enlarged mind perceived at once, and fully vindicated its importance. The very name of Medical Police, is now sufficient to attract the attention of legislators and of magistrates, and to make them desirous of becoming acquainted with its principles, and anxious to see them carried into execution. In fact, its influence is already visible in the countries where it is cultivated. If the principles of medical police were separated from the professional part of medicine, and communicated in a form generally intelligible, in what country have we reason to expect more beneficial effects from its influence than this? Where is the spirit of patriotism and benevolence so prevalent? What nation is more generous in its public institutions. Where does the individual sacrifice a part of his wealth so willingly for the benefit of the community? It seems only necessary to prove that an undertaking will be of advantage to the state, to have it carried into instant execution. But, can medical knowledge be more usefully employed than in pointing out the means of preserving or improving health; of supplying healthy nourishment to the poor, especially in times of scarcity; of opposing the introduction of contagious diseases, and of checking their progress; of securing to the indigent the advantages intended by their benefactors; of rearing the orphan to be the support of the nation which has adopted him; and of diminishing the horrors of confinement to the poor maniac and the criminal? These good effects are not to be promoted so much by rigid laws, as by recommendation and example. Nor can it be reasonably objected to a system of medical police, that it is a pleasing dream, which flatters the imagination, but the execution of which is in reality impracticable. As well might we entirely throw aside the rules of humanity, because no one is able to observe them all; or live without laws, because no existing code is unexceptionable.

Medical police may be defined,—The application of the principles deduced from the different branches of medical knowledge, for the promotion, preservation and restoration of general health.

The effects to be expected from it are the general welfare of the state, and increase of healthy population; and are to be attained by means of public institutions, express laws, and popular instruction. Instructing the people, and convincing them of the propriety of certain precautions and attentions, in regard to their own and the general state of health, are necessary to secure the good effects of our public institutions and regulations; to obtain respect and obedience in many things, to which no express law can be adapted; and, to induce them to forego what may be prejudicial to the safety of the community, and of themselves.

Public medical institutions and laws, must be adapted to the country for which they are intended. Many local circumstances, national character, habits of life, prevalent customs and professions, situation, climate, &c. make considerable varieties necessary. And many institutions, many a law which would be highly beneficial to the public health, in some circumstances, would be useless, impracticable, and even hurtful, in others. These causes and their effects, must, therefore, be particularly attended to.

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The principal authors who have written on this subject, are Alberti, Heister, Plaz, Frank, Hussty, Metzger, and Hebenstreit; to whom we may add Howard and Rumford.

The subjects which it comprehends, cannot be classed very regularly or systematically. Its views will be different, according to occasional and temporary causes; and its interference may sometimes be advantageously extended beyond what may seem the strict limits of a branch of the medical profession.

MEDICAL POLICE RELATES TO

THE SITUATION OF PLACES OF ABODE. Construction of houses.

AIR. Means of counteracting its impurity—Its various impregnations.

WATER. Its necessity and purity.

FOOD. Its various kinds—Comparative quantities of nourishment afforded by them—Cheaper kinds, which may be safely substituted in times of scarcity—Bread—Animal food—Butcher meat—Fish—Vegetables—Vessels—Cookery; Healthy; Œconomical.

DRINK. Beer—Ale—Porter—Cyder—Spirituous liquors—Wine—Warm drinks—Adulterations of these liquors—Hurtful additions—Vessels.

FIRE and LIGHT.

CLOTHING.

CLEANLINESS.

PROFESSIONS. Manufacturers—Mechanics—Soldiers—Sailors—Men of letters.

HEALTHY PROPAGATION.

PREGNANT and PUERPERAL WOMEN.

NEW-BORN INFANTS. Registers of birth.

PHYSICAL EDUCATION.

PREVENTION of ACCIDENTS. From poison—Hurtful Effluvia—Maniacs—Rabid animals.

RESTORATION of the APPARENTLY DEAD. Humane Societies—Care of the dying—Danger of too early—too late burial—Places of Interment—manner of conducting it—Bills of mortality.

CONTAGIOUS and EPIDEMIC DISEASES. Plague—Putrid fever—Dysentery—Smallpox—Inoculation—Extirpation of them—Leprosy—Itch and pox—Precautions to be taken, to prevent their introduction, to diminish their violence, to destroy their cause, and to counteract their effects.

MANAGEMENT of PUBLIC INSTITUTIONS in which many people are collected under the care of the public.

Hospitals for the Indigent:

1. Lying-in Hospitals.
2. Foundling ditto.
3. Orphan ditto.
4. Hospitals for Education.

5. Aged

Means of preserving Health.

5. Aged.
6. Blind.
7. Maimed.

Military Hospitals:
Prisoners of War.
Lazarettoes.
Work-houses.
Prisons.
Hospitals for the Sick.
Maniacs.
Convalescents.
Incurables.

Observations on the MEANS *of preserving* HEALTH.

Having now treated of all the most important diseases to which the human body is subjected, we shall conclude the article MEDICINE, with a few observations on the means of preserving health, both for the general management of valetudinarians, and of those also who wish to obtain long life and good health by avoiding the causes of those diseases which the human species often bring upon themselves. On this subject much has been written at almost every period of medicine. And we may refer those readers who wish for a full and extensive view of this interesting subject to a very elaborate work lately published by Sir John Sinclair, Bart. entitled the Code of Health and Longevity. Here we cannot propose to give even an abridged view of this extensive inquiry; but must content ourselves with offering only a very few general observations.

13 I. RULES *for the Management of* VALETUDINARIANS.

THAT part of the medical system which lays down rules for the preservation of health, and prevention of diseases, termed *Hygieina*, is not to be strictly understood as if it respected only those people who enjoy perfect health, and who are under no apprehensions of disease, for such seldom either desire or attend to medical advice; but is rather considered as relating to valetudinarians, or such as, though not actually sick, may yet have sufficient reason to fear that they will soon become so: hence it is that the rules must be applied to correct morbific dispositions, and to obviate various particulars which were shown to be the remote or possible causes of diseases.

From the way in which the several temperaments are commonly mentioned by systematic writers, it should seem as if they meant that every particular constitution might be referred to one or other of the four; but this is far from being the case, since by much the greater number of people have temperaments so indistinctly marked, that it is hard to say to which of the temperaments they belong.

When we actually meet with particular persons who have evidently either,

1. Too much strength and rigidity of fibre, and too much sensibility;

2. Too little strength, and yet too much sensibility;

3. Too much strength, and but little sensibility; or,

4. But little sensibility joined to weakness;

we should look on such persons as more or less in the valetudinary state, who require that these morbific dispositions be particularly watched, lest they fall into those diseases which are connected with the different temperaments.

People of the first-mentioned temperament being liable to suffer from continued fevers, especially of the inflammatory species, their scheme of preserving health should consist in temperate living, with respect both to diet and exercise: they should studiously avoid immoderate drinking, and be remarkably cautious lest any of the natural discharges be checked. People of this habit bear evacuations well, especially bleeding: they ought not, however, to lose blood but when they really require to have the quantity lessened; because too much of this evacuation would be apt to reduce the constitution to the second-mentioned temperament, in which strength is deficient, but sensibility redundant.

Persons of the second temperament are remarkably prone to suffer from painful and spasmodic diseases, and are easily ruffled; and those of the softer sex who have this delicacy of habit, are very much disposed to hysterical complaints. The scheme here should be, to strengthen the solids by moderate exercise, cold bathing, cinchona, and chalybeate waters; particular attention should constantly be had to the state of the digestive organs, to prevent them from being overloaded with any species of saburra which might engender flatus, or irritate the sensible membranes of the stomach and intestines, from whence the disorder would soon be communicated to the whole nervous system. Persons of this constitution should never take any of the drastic purges, or strong emetics; neither should they lose blood but in cases of urgent necessity. But a principal share of management, in these extremely irritable constitutions, consists in avoiding all sudden changes of every sort, especially those with respect to diet and clothing, and in keeping the mind as much as possible in a state of tranquillity: hence the great advantages which people of this frame derive from the use of medicinal waters drank on the spot, on account of that freedom from care and serious business of every kind, which generally obtains in all the places planned for the reception of valetudinarians.

The third-mentioned temperament, where there is an excess of strength and but little sensibility, does not seem remarkably prone to any distressing or dangerous species of disease; and therefore it can hardly be supposed that persons so circumstanced will either of themselves think of any particular scheme of management, or have recourse to the faculty for their instructions: such constitutions, however, we may observe, bear all kinds of evacuations well, and sometimes require them to prevent an over-fulness, which might end in an oppression of the brain or some other organ of importance.

But the fourth temperament, where we have weakness joined to want of sensibility, is exceedingly apt to fall into tedious and dangerous diseases, arising from a defect of absorbent power in the proper sets of vessels, and from languor of the circulation in general; whence corpulency, dropsy, jaundice, and different degrees of scorbutic affection. In order to prevent these, or any other species of accumulation and depravation of the animal fluids, the people of this constitution should use a generous course of diet, with brisk exercise,

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exercise, and be careful that none of the secretions be interrupted, nor any of the natural discharges suppressed. These constitutions bear purging well, and often require it; as also the use of emetics, which are frequently found necessary to supply the place of exercise, by agitating the abdominal viscera, and are of service to prevent the stagnation of bile, or the accumulation of mucous humours, which hinder digestion, and clog the first passages. The free use of mustard, horse-radish, and the like sort of stimulating dietetics, is serviceable in these torpid habits.

When the general mass of fluids is increased beyond what is conducive to the perfection of health, there arises what the writers term a *plethora*, which may prove the source of different diseases; and therefore, when this overfulness begins to produce languor and oppression, care should be taken in time to reduce the body to a proper standard, by abridging the food and increasing the natural disharges, using more exercise, and indulging less in sleep.

But in opposite circumstances, where the fluids have been exhausted, we are to attempt the prevention of further waste by the use of strengthening stomachics, nourishing diet, and indulgence from fatigue of body or mind.

Vitiated fluids are to be considered as tainted either with the different kinds of general acrimony, or as betraying signs of some of the species of morbific matter which give rise to particular diseases, such as calculus, scurvy, &c.

During the state of infancy, we may sometimes observe a remarkable acidity, which not only shows itself in the first passages, but also seems to contaminate the general mass of fluids. As it takes its rise, however, from weak bowels, our views, when we mean to prevent the ill consequences, must be chiefly directed to strengthen the digestive organs, as on their soundness the preparation of good chyle depends; and hence small doses of rhubarb and chalybeates (either the natural chalybeate waters mixed with milk, or the *murias ammoniæ et ferri* in doses of a few grains, according to the age of the child), are to be administered; and the diet is to be so regulated as not to add to this acid tendency: brisk exercise is likewise to be enjoined, with frictions on the stomach, belly, and lower extremities.

Where the fluids tend to the putrescent state, which shows itself by fetid breath, sponginess and bleeding of the gums, a bloated look and livid cast, the diet then should be chiefly of fresh vegetables and ripe fruits, with wine in moderation, due exercise, and strengthening bitters.

Where acrimony shows itself by itching eruptions, uncommon thirst, and flushing heats, nothing will answer better than such sulphureous waters as the Harrowgate and Moffat, at the same time using a course of diet that shall be neither acrid nor heating.

So far with respect to those kinds of morbific matter, which do not invariably produce a particular species of disease; but there are others of a specific nature, some of which are generated in the body spontaneously, and seem to arise from errors in diet, or other circumstances of ill management with respect to the animal economy; and hence it is sometimes possible, to a certain degree if not altogether, to prevent the ill consequences. Thus, there are instances where returns of the gout have been prevented by adhering strictly to a milk diet.

The rheumatism has also been sometimes warded off by wearing a flannel shirt, or by using the cold bath without interruption.

Calculus may be retarded in its progress, and prevented from creating much distress, by the internal use of soap and lime-water, by soap-lees taken in milk or in veal-broth, or by the use of aërated alkaline water, which may perhaps be considered as being both more safe and more efficacious, and at the same time more pleasant than any of the other practices.

The scurvy may be prevented by warm clothing and perseverance in brisk exercise, by drinking wine or cyder, and eating freely of such vegetable substances as can be had in those situations where this disease is most apt to show itself.

In constitutions where there is an hereditary disposition to the scrophula, if early precautions be taken to strengthen the solids by cold bathing, a nourishing course of diet, and moderate use of wine, the constitution which gives rise to the disease will probably be prevented from producing any very bad effects.

The other kinds of morbific matter, which are of the specific nature, are received into the body by infection or contagion.

The infection of a putrid fever or dysentery is best prevented by immediately taking an emetic on the first attack of the sickness or shivering; and if that do not completely answer, let a large blister be applied between the shoulders: by this method the nurses and other attendants on the sick in the naval hospitals have often been preserved. As to other infectious morbific matter, we must refer to what has already been said when treating of hydrophobia, poisons, gonorrhœa, &c.

The ill effects which may arise from the different species of saburra, are to be obviated, in general, by the prudent administration of emetics, and carefully abstaining from such kinds of food as are known to cause the accumulation of noxious matters in the first passages.

Crude vegetables, milk, butter, and other oily substances, are to be avoided by persons troubled with a sourness in the stomach; brisk exercise, especially riding, is to be used, and they are to refrain from fermented liquors: the common drink should be pure water; or water with a very little of some ardent spirit, such as rum or brandy. Seltzer or Pyrmont waters are to be drunk medicinally; and aromatic bitters, infusions, or tinctures, acidulated with sulphuric acid, will be found serviceable, in order to strengthen the fibres of the stomach, and promote the expulsion of its contents, thereby preventing the too hasty fermentation of the alimentary mixture. In order to procure immediate relief, magnesia alba, or *creta præparata*, will seldom fail; the magnesia, as well as the chalk, may be made into lozenges, with a little sugar and mucilage; and in that form may be carried about and taken occasionally by people afflicted with the acid saburra.

In constitutions where there is an exuberance or stagnation of bile, and a troublesome bitterness in the mouth, it is necessary to keep the bowels always free, by taking occasionally small doses of pure aloes, *oleum ricini*,

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ricini, supertartrite of potass, some of the common purging salts, or the natural purging waters.

When there is a tendency to the empyreumatic and rancid saburra, people should carefully avoid all the various kinds of those oily and high-seasoned articles of diet generally termed *made-dishes*, and eat sparingly of plain meat, without rich sauces or much gravy; and in these cases the most proper drink is pure water.

II. RULES *for those who enjoy perfect* HEALTH.

THERE can be no doubt, that, in general, temperance is the true foundation of health; and yet the ancient physicians, as we may see in the rules laid down by Celsus, did not scruple to recommend indulgence now and then, and allowed people to exceed both in eating and drinking; but it is safer to proceed to excess in drink than in meat; and if the debauch should create any extraordinary or distressing degree of pain or sickness, and a temporary fever should ensue, there are two ways of shaking it off, either to lie in bed and encourage perspiration, or to get on horseback, and by brisk exercise restore the body to its natural state. The choice of these two methods must always be determined by the peculiar circumstances of the parties concerned, and from the experience which they may before have had which agrees best with them.

If a person should commit excess in eating, especially of high-seasoned things, with rich sauces, a draught of cold water, acidulated with sulphuric acid, will take off the sense of weight at the stomach, and assist digestion by moderating and keeping within bounds the alimentary fermentation, and thus preventing the generation of too much flatus. The luxury of ices may be here of real service at the tables of the great, as producing similar effects with the cold water acidulated. Persons in these circumstances ought not to lay themselves down to sleep, but should keep up and use gentle exercise until they are sensible that the stomach is unloaded, and that they no longer feel any oppressive weight about the præcordia.

If a man be obliged to fast, he ought, if possible, during that time, to avoid laborious work: after suffering severe hunger, people ought not at once to gorge and fill themselves; nor is it proper, after being overfilled, to enjoin an absolute fast: neither is it safe to indulge in a state of total rest immediately after excessive labour, nor suddenly fall hard to work after having been long without motion: in a word, all changes should be made by gentle degrees; for though the constitution of the human body be such that it can bear many alterations and irregularities without much danger; yet, when the transitions are extremely sudden, there is a great risk of producing some degree of disorder.

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It is also the advice of Celsus to vary the scenes of life, and not confine ourselves to any settled rules: but as inaction renders the body weak and listless, and exercise gives vigour and strength, people should never long omit riding, walking, or going abroad in a carriage. Fencing, playing at tennis, dancing, or other similar engagements, which afford both exercise and amusement, as each shall be found most agreeable or convenient, are to be used in turn, according to the circumstances and tendency to any particular species of disease. But when the weakness of old age shall have rendered the body incapable of all these, then dry frictions with the flesh-brush will be very requisite to preserve health, by accelerating the flow of humours through the smallest orders of vessels, and preventing the fluids from stagnating too long in the cellular interstices of the fleshy parts.

Sleep is the great restorer of strength; for, during this time, the nutritious particles appear to be chiefly applied to repair the waste, and replace those that have been abraded and washed off by the labour and exercise of the day; but too much indulgence in sleep has many inconveniences, both with respect to body and mind, as it blunts the senses, and encourages the fluids to stagnate in the cellular membrane; whence corpulency, and its necessary consequences languor and weakness.

The proper time for sleep is the night, when darkness and silence naturally bring it on: sleep in the daytime, from noise and other circumstances, is in general not so sound or refreshing; and to some people is really distressful, as creating an unusual giddiness and languor, especially in persons addicted to literary pursuits. Custom, however, frequently renders sleep in the day necessary; and in those constitutions where it is found to give real refreshment, the propensity to it ought to be indulged, particularly in very advanced age.

With regard to the general regimen of diet, it has always been held as a rule, that the softer and milder kinds of aliment are most proper for children and younger subjects: that grown persons should eat what is more substantial; and old people lessen their quantity of solid food, and increase that of their drink both of the diluent and cordial kind. For full information on the subject of Diet and Regimen, see the article DIETETICS in the SUPPLEMENT.

INDEX.

Spina

Inflammatio[n]

Spina

Medicis.

MEDICIS, Cosmo de, was born in the year 1389, and was in the prime of life, at the death of his father Giovanni. His conduct was distinguished for urbanity and kindness to the superior ranks of his fellow-citizens, and by a constant attention to the wants of the lower class, whom his munificence abundantly relieved. His prudence and moderation, however, could not repress the ambitious designs of the rival families, the Florentines and Medici; for in 1433, Rinaldo de Albizi, at the head of a formidable party, carried the appointment of the magistracy. On returning from his country seat he was seized upon by his adversaries, and committed to prison. The conspirators not agreeing as to the proper method of dispatching their prisoner, one Peruzzi recommended poison, which was heard by Cosmo, who refused to take any other sustenance than a small portion of bread. In this dismal situation he remained four days, shut up from all his kindred and friends, where he soon expected to be numbered with the dead. But the man employed to take him off, unexpectedly proved his friend. Malavolta, the keeper of the prison, relented, and declared that he had no just reason to be alarmed, as he hesitated not to eat of every thing that was brought him.

His brother Lorenzo, and his cousin Averardo, raised a considerable body of men in Romagna and other districts; and being joined by the commander of the republican forces, they marched to Florence to relieve him. A decree was obtained from the magistracy, by which he was banished to Padua for ten years, his brother to Venice for five, and several of their relations shared a similar fate. Padua was in the dominions of Venice, and he received a deputation from the senate before he reached it, promising him their protection and assistance in whatever he should desire. He rather experienced the treatment of a prince than of an exile, as they entertained the highest expectations from his great commercial knowledge. From this period his life may be considered as one continued scene of uninterrupted prosperity, and his family received education equal to that of the greatest potentates. In his public and private charities he was almost unbounded, and perhaps possessed more wealth than any single individual in Europe at that period. In his promotion of science and encouragement of learned men he was truly exemplary, and from this source he acquired the greatest honour and esteem.

His fostering hand protected the arts as well as the sciences; and architecture, sculpture, and painting, all flourished under his powerful protection. The countenance he showed to these arts was not such as their professors generally receive from the great; for the sums of money which he expended on pictures, statues, and public buildings, appear almost incredible. When he approached the period of his mortal existence, his faculties were still unimpaired; and 20 days before he died, he requested Ficino to translate from the Greek the treatise of Xenocrates on death. He died on the 1st of August 1464, at the age of 75, and gave strict injunctions, that his funeral should be conducted with as much privacy as possible. By public decree he was honoured with the title of *Pater Patriæ*, an appellation which was inscribed on his tomb, and was declared by competent judges, to be founded in real merit.

Medici, *Lorenzo de*, stiled, with great propriety, the Magnificent, was the grandson of Cosmo, and about 16 years of age at his decease. In 1469 his father died, and he succeeded to his authority as if it had constituted a part of his fortune. In the year 1474, Lorenzo incurred the displeasure of the pope for the opposition he

Medicis. he made to some of his encroachments on the petty princes of Italy, and for this reason he deprived him of the office of treasurer of the Roman see, which he conferred on one Pazzi, connected with a Florentine family, the interest of which he thus secured, and intended to sacrifice Lorenzo and Juliano to his private revenge. Their assassination was fixed for Sunday, April 26. 1478, and the cathedral was the place in which a monster of an archbishop had resolved to murder them by the instigation of the pope. When the people saw one of their favourites (Juliano) expiring, and the other (Lorenzo) covered with blood, their rage was not to be expressed in language. The interference of the magistrates was finally victorious, who had the courage and virtue to hang the archbishop from one of the windows, arrayed in his pontifical robes, which made Florence resound with the acclamation—Medici, Medici! down with their enemies!

Lorenzo was delivered from that part of the cathedral to which he had fled for refuge, and was triumphantly carried home, where his wounds were attended to by men of ability. His friends in the mean time pursued the conspirators, and spared none who happened to fall in their way. In a word, the generality of them were either hanged or decapitated, and very few had the good fortune to escape their uncommon vigilance. Much to the honour of Lorenzo, he exerted all his influence to prevent the indiscriminate massacre of his cruel enemies, and restrain the just indignation of the people, begging that they would trust the magistrates with the punishment of the guilty; and the respect in which he was held had the most astonishing effect in restraining the vengeance of popular indignation.

No sooner had hostilities ceased between Pope Sextus and the Florentine republic, than Lorenzo began to develope plans for securing the internal peace and tranquillity of Italy, by which the highest honour has been conferred on his political life. But the life of this great man was again brought into imminent danger by the intrigues of Cardinal Riario, and some Florentine exiles, who determined to assassinate him in the church of the Carmeli, on the festival of the Ascension 1481; but the plot was happily discovered, the conspirators were executed, and after this Lorenzo very seldom went abroad without being surrounded by a number of friends in whom he could securely confide.

When we attentively examine the character of Lorenzo, it will not perhaps appear astonishing, that Italy, Christendom, and even the Mahometans themselves, conferred upon him the most flattering approbation. Even Prince Mirandola chose Florence as the place of his residence entirely upon his account, and there ended his mortal career. To a most engaging person Lorenzo added almost every other accomplishment. He was the favourite of the ladies, the envy of his own sex, and the admiration of all. He was declared to be unrivalled in chivalry, and one of the most eminent orators that the world in any age has produced. According to the opinion of his contemporaries, he was even superior to Julius Cæsar himself, except as a general, yet he would also have proved a most consummate commander had not peace been always the darling of his soul. We recollect a memorable passage in the Rambler, which may here be appositely introduced. A great man condescending to do little things, is like the sun in his western declination; he remits his splendor, but retains his magnitude, and pleases more though he dazzles less. To such little things did Lorenzo frequently submit, often seeking pleasure in his nursery, and spending hours there in all the frivolous pranks of childish diversion. The gravity of his life, if contrasted with its levity, must make him appear as a composition of two different persons, incompatible, and, as it were, impossible to be joined the one with the other.

Such were the love and veneration of the citizens for Lorenzo, that the physician who attended him on his deathbed, terrified to return to Florence, left the house in a state of distraction, and plunged himself into a well. When Ferdinand king of Naples was informed of his death, he cried out, "This man has lived long enough for his own glory, but too short a time for Italy." He died on the 8th of April 1492, amidst a number of his weeping friends, who appeared deeply conscious of such an irreparable loss.

Medicis, *John de*, on account of his bravery and knowledge in military affairs, was surnamed the *Invincible*. He was the son of John, otherwise called *Jourdain*, de Medicis. His only son Cosmo I. styled the *Great*, was chosen duke of Florence after the murder of Alexander de Medicis, A. D. 1537. He first carried arms under Laurence de Medicis against the duke of Urbino, afterwards under Pope Leo X. Upon the death of Leo, he entered into the service of Francis I. which he quitted to follow the fortune of Francis Sforza duke of Milan. When Francis I. formed an alliance with the pope and the Venetians against the emperor, he returned to his service. He was wounded in the knee at Governola, a small town in the Mantuan territory, by a musket ball; and being carried to Mantua, he died the 29th of November 1526, aged 28. Brantome relates, that when his leg was to be cut off, and when he was informed that he needed some person to support him, "Proceed without fear (said he), I need nobody!" and he held the candle himself during the operation. This anecdote is also mentioned by Varchi. John de Medicis was above the middle stature, strong, and nervous. His soldiers, to express their affection for him and their concern for his loss, assumed a mourning dress and standards, which gave the name of *the black band* to the Tuscan troops whom he commanded.

Medicis, *Laurence* or *Laurenein de*, was descended from a brother of Cosmo the Great, and affected the name of *popular*. In 1537, he killed Alexander de Medicis, whom Charles V. had made duke of Florence, and who was believed to be the natural son of Laurence de Medicis duke of Urbino. He was jealous of Alexander's power, and disguised this jealousy under the specious pretext of love to his country. He loved men of learning, and cultivated literature. His works are, 1. *Lamenti*, Modena, 12mo. 2. *Acidosio Commedia*, Florence 1595, 12mo. He died without issue.

Medicis, *Hypolitus de*, natural son of Julian de Medicis and a lady of Urbino, was early remarkable for the brilliancy of his wit and the graces of his person. Pope Clement VII. his cousin, made him cardinal in 1529, and sent him as legate into Germany to the court of Charles V. When that prince went into Italy, Medicis, yielding to his warlike disposition, appeared

Medicis. appeared in the dress of an officer, and advanced before the emperor, followed by several respectable gentlemen of the court. Charles, naturally suspicious, and afraid that the legate intended to do him some ill offices with the pope, sent after him and caused him to be apprehended. But when he understood that it was a mere sally of humour in the young cardinal, he set him at liberty in a few days. The character which Medicis obtained by the happy success of this appointment was of essential service to him. He was considered as one of the Supports of the Holy See; and a little before Clement's death, when the corsair Barbarossa made a descent into Italy to the great terror of Rome, which was only defended by 200 of the pope's guards, Medicis was despatched to protect the coasts from the fury of the barbarians. On his arrival at the place of destination, he was fortunate enough to find that Barbarossa had withdrawn himself at that critical moment; which allowed him to claim the honour of the retreat without exposing his person or his army. When he returned to Rome, he was of great service in the election of Paul III. who nevertheless refused to make him legate to Ancona, though that office had been promised to him in the conclave. Enraged also that the pope had bestowed the principality of Florence on Alexander de Medicis, supposed to be the natural son of Laurence duke of Urbino, he was prompted by his ambition to believe that he might succeed to that dignity by the destruction of Alexander. He entered into a conspiracy against him, and determined to carry him off by a mine; but the plot was discovered before he had accomplished his purpose. Octavian Zanga, one of his guards, was arrested as his chief accomplice. Hypolitus de Medicis, apprehensive for his own safety, retired to a castle near Tivoli. On his road to Naples, he fell sick at Itri in the territory of Fondi, and died August 13. 1535, in his 24th year, not without suspicion of being poisoned. His house was an asylum for the unfortunate, and frequently for those who were guilty of the blackest crimes. It was open to men of all nations; and he was frequently addressed in twenty different languages. He had a natural son named *Asdrubal de Medicis*, who was a knight of Malta. This anecdote proves that his manners were more military than ecclesiastic. He wore a sword, and never put on the habit of cardinal except on occasions of public ceremony. He was wholly devoted to the theatre, hunting, and poetry.

Medicis, *Alexander de*, first duke of Florence in 1530, was natural son of Laurence de Medicis, surnamed the *Younger*, and nephew of Pope Clement VII. He owed his elevation to the intrigues of his uncle and to the arms of Charles V. This prince having made himself master of Florence after an obstinate siege, conferred the sovereignty of this city on Alexander, and afterwards gave him in marriage Margaret of Austria his natural daughter. According to the terms of capitulation granted to the Florentines, the new duke was to be only hereditary doge, and his authority was tempered by councils; which left them at least a shadow of their ancient liberty. But Alexander, who felt himself supported by the emperor and the pope, was no sooner in possession of his new dignity, than he began to govern like a tyrant; being guided by no law but his own caprice, indulging the most brutal passions, and making light of dishonouring families, and of violating even the asylum of the cloisters to gratify his lust. Among the confidants of his debauchery was a relation of his own, Laurence de Medicis. This young man, who was only 22 years of age, at the instigation of Philip Strozzi, a zealous republican, conceived the design of assassinating Alexander, and thereby of delivering his country from oppression. From the moment when he first became attached to him, he tried to gain his confidence, for no other reason but that he might the better have it in his power to take away his life. A considerable time elapsed before he found such an opportunity as he desired. At length, under pretence of procuring the duke a *tête à tête* with a lady of whom he was deeply enamoured, he brought him alone and unattended into his chamber, and put him under his bed. He went out, under pretence of introducing the object of his passion; and returned along with an assassin by profession, to whom alone he had entrusted his design, only to stab him. This cruel scene happened on the night betwixt the 5th and 6th of January 1537. Alexander was only 26 years of age. The Florentines derived no advantage from this crime of Laurence, for they failed in their attempt to recover their liberty. The party of the Medicis prevailed, and Alexander was succeeded by Cosmo: whose government, it must be confessed, was as just and moderate, as that of his predecessor had been violent and tyrannical. Laurence de Medicis fled to Venice, to some of the leaders of the malecontents at Florence, who had taken refuge there; but not thinking himself in sufficient security, he went to Constantinople, whence he returned some time after to Venice. He was there assassinated in 1547, ten years after the duke's murder, by two soldiers, one of whom had formerly been in Alexander's guards. And these soldiers were generous enough to refuse a considerable sum of money, which was the price put upon his head.

Medicis, *Cosmo de*, grand duke of Tuscany, joined Charles V. against the French, after trying in vain to continue neutral. As a reward for his services, the emperor added to the duchy of Tuscany Piombino, the isle of Elba, and other states. Cosmo soon after received from Pope Pius IV. the title of *grand duke*, and had it not been opposed by all the princes of Italy, this pontiff, who was entirely devoted to Cosmo, because he had thought proper to acknowledge him to be of his house, would have conferred on him the title of *king*. There never was a more zealous patron of learning. Ambitious of imitating the second Cæsar, he like him, was fond of learned men, kept them near his person, and founded for them the university of Pisa. He died in 1574, at the age of 55, after governing with equal wisdom and glory. In 1562 he instituted the military order of St Stephen. His son, Francis Mary who died in 1587, was the father of Mary of Medicis, the wife of Henry the Great and of Ferdinand I. who died in 1608.

Medici. Medietas

MEDIETAS linguæ, in *Law*, signifies a jury, or inquest impanelled, of which the one half are natives of this land and the other foreigners. This jury is never used except where one of the parties in a plea is a stranger and the other a denizen. In petit treason, murder,

murder, and felony, foreigners are allowed this privilege; but not in high treason, because an alien in that case shall be tried according to the rules of the common law, and not by a *medietas linguæ*. A grand jury ought not in any case to be of a *medietas linguæ*; and the person that would have the advantage of a trial in this way, is to pray the same, otherwise it will not be permitted on a challenge of the jurors.

MEDIMNUS, in Grecian antiquity, a measure of capacity. See MEASURE.

MEDINA TALNABI, a famous town of Arabia Petræa, between Arabia Deserta and Arabia the Happy; celebrated for being the burial-place of Mahomet. It stands at a day's journey from the port of Iambo. It is of moderate size, surrounded by wretched walls, and situated in the midst of a sandy plain. It belongs to the scherif of Mecca, although it had of late times a particular sovereign of the family of Dacii Barkad. At present the government is confided by the scherif to a vizir, who must be taken from the family of the sovereign. Before Mahomet, this city was called *Iathreb*; but it got the name of *Medinet en Nebbi*, "the City of the Prophet," after Mahomet, being driven from Mecca by the Koreischites, had taken refuge there, and passed in it the rest of his days. The tomb of Mahomet at Medina is respected by Mussulmans, but they are under no obligation to visit it for the purposes of devotion. The caravans of Syria and Egypt alone, which on their return from Mecca pass near Medina, go a little out of their way to see the tomb. It stands in a corner of the great square, whereas the Kaba is situated in the middle of that at Mecca. That the people may not perform some superstitious worship to the relics of the prophet, they are prevented from approaching the tomb by gates, through which they may look at it. It consists of a piece of plain mason work in the form of a chest, without any other monument. The tomb is placed between two others, where the ashes of the two first caliphs repose. Although it is not more magnificent than the tombs of the greater part of the founders of mosques, the building that covers it is decorated with a piece of green silk stuff embroidered with gold, which the pacha of Damascus renews every seven years. It is guarded by 40 eunuchs, who watch the treasure said to be deposited there. It is seated in a plain abounding with palm trees, in E. Long. 57. 10. N. Lat. 25. See (*History of*) ARABIA.

MEDINA *Celi*, an ancient town of Spain, in Old Castile, and capital of a considerable duchy of the same name; seated near the river Xalon, in W. Long. 2. 9. N. Lat. 41. 15.

MEDINA *de-las-Torres*, a very ancient town of Spain, in Estremadura, with an old castle, and the title of a duchy. It is seated on the confines of Andalusia, at the foot of a mountain near Badajoz.

MEDINA-*del-Campo*, a large, rich, and ancient town of Spain, in the kingdom of Leon. The great square is very fine, and adorned with a superb fountain. It is a trading place, enjoys great privileges, and is seated in a country abounding with corn and wine. W. Long. 4. 20. N. Lat. 41. 22.

MEDINA-*del-rio-Secco*, an ancient and rich town of Spain, in the kingdom of Leon, with the title of a duchy: seated on a plain, remarkable for its fine pastures. E. Long. 4. 33. N. Lat. 42. 8.

MEDINA, SIR JOHN, an eminent painter, was son of Medina de l'Asturias, a Spanish captain, who settled at Brussels, where the son was born in 1660. He was instructed in painting by Du Chatel; under whose direction he made great progress; and applying himself to the study of Rubens, made that eminent master his principal model. He painted both history and portrait; and was held in extraordinary esteem by most of the princes of Germany, who distinguished his merit by several marks of honour. He married young, and came into England in 1686, where he drew portraits for several years with great reputation; as he painted those subjects with remarkable freedom of touch, a delicate management of tints, and strong resemblance of the persons. The earl of Leven encouraged him to go to Scotland, and procured him a subscription of 500l. worth of business. He went, carrying a large number of bodies and postures, to which he painted heads. He returned to England for a short time; but went back to Scotland, where he died, and was buried in the churchyard of the Grayfriars at Edinburgh, in 1711, aged 52. He painted most of the Scotch nobility. Two small history pieces, and the portraits of the professors, in the Surgeons Hall at Edinburgh, were also painted by him. At Wentworth castle is a large piece containing the first duke of Argyll and his sons, the two late dukes John and Archibald, in Roman habits; the style Italian, and superior to most modern performers. The duke of Gordon presented Sir John Medina's head to the great duke of Tuscany for his collection of portraits done by the painters themselves; the duke of Gordon too was drawn by him, with his son the marquis of Huntly and his daughter Lady Jane, in one piece. Medina was knighted by the duke of Queensberry, lord high commissioner; and was the last knight made in Scotland before the union. The prints in the octavo edition of Milton were designed by him: and he composed another set for Ovid's Metamorphoses, but they were never engraved.

MEDINE, an Egyptian piece of money of iron silvered over, and about the size of a silver threepence.

MEDIOLANUM, an ancient city, the capital of the Insubres, built by the Gauls on their settlement in that part of Italy; a *municipium*, and a place of great strength; and a seat of the liberal arts; whence it had the name of *Novæ Athenæ*. Now *Milan*, capital of the Milanese, situated on the rivers Olana and Lombro. E. Long. 9. 30. N. Lat. 45. 25.

MEDIOLANUM *Aulercorum*, in *Ancient Geography*, a town of Gallia Celtica, which afterwards took the name of the *Eburovicum Civitas* (Antonine); corrupted to *Civitas Ebroicorum*, and this last to *Ebroica*; whence the modern appellation *Evreux*, a city of Normandy. E. Long. 1. 12. N. Lat. 49. 41.

MEDIOLANUM *Gugernorum*, in *Ancient Geography*, a town of Gallia Belgica; now the village *Moyland*, not far from Cologne.

MEDIOLANUM *Ordovicum*, in *Ancient Geography*, a town of Britain, now *Llan Vethlin*, a market town of Montgomeryshire in Wales.

MEDIOLANUM *Santonum*, in *Ancient Geography*, which afterwards taking the name of the people, was called

called *Santonica Urbs*; also *Santones* and *Santoni*: A town of Aquitaine. Now *Saintes*, capital of Saintonge in Guienne, on the river Charente.

MEDIOMATRICI, anciently a territory of Belgica. Now the diocese of Metz.

MEDITATION, an act by which we consider any thing closely, or wherein the soul is employed in the search or consideration of any truth. In our religion, it is used to signify a consideration of the objects and grand truths of the Christian faith.

Mystic divines make a great difference between *meditation* and *contemplation*: the former consists in discursive acts of the soul, considering methodically and with attention the mysteries of faith and the precepts of morality; and is performed by reflections and reasonings, which leave behind them manifest impressions on the brain. The pure contemplative have no need of meditation, as seeing all things in God at a glance, and without any reflection. When a man, therefore, has once quitted meditation, and is arrived at contemplation, he returns no more; and, according to Alvarez, never resumes the oar of meditation, except when the wind of contemplation is too weak to fill his sails.

MEDITERRANEAN, something enclosed within land; or that is remote from the ocean.

MEDITERRANEAN is more particularly used to signify that large sea which flows between the continents of Europe and Africa, entering by the straits of Gibraltar, and reaching into Asia, as far as the Euxine sea and the Palus Mæotis.

The Mediterranean was anciently called the *Grecian sea* and the *Great sea*. It is now cantoned out in several divisions, which bear several names. To the west of Italy it is called the *Ligustic* or *Tuscan sea*; near Venice, the *Adriatic*; towards Greece, the *Ionic* and *Ægean*; between the Hellespont and the Bosphorus, the *White sea*, as being very safe; and beyond, the *Black sea*, its navigation being dangerous.

The British trade carried on by means of the Mediterranean sea, is of the last consequence to Great Britain; and the permanent preservation thereof depends on the possession of the town and fortification of Gibraltar.

The counterfeiting of Mediterranean passes for ships to the coast of Barbary, &c. or the seal of the admiralty office to such passes, is felony, without benefit of clergy. Stat. 4. Geo. II. c. 18.

MEDITRINALIA, a Roman festival in honour of the goddess Meditrina, kept on the 30th of September. Both the deity and the festival were so called *à medendo*, because on this day they began to drink new wine mixed with old by way of medicine. The mixture of wines, on this festival, was drank with much form and solemn ceremony.

MEDITULLIUM, is used by anatomists for that spongy substance between the two plates of the *cranium*, and in the interstices of all laminated bones. See ANATOMY, N° 1. 11.

MEDIUM, in *Logic*, the mean or middle term of a syllogism, being an argument, reason, or consideration, for which we affirm or deny any thing; or, it is the cause why the greater extreme is affirmed or denied of the less in the conclusion.

MEDIUM, in *Arithmetic*, or *arithmetical medium* or *mean*, called in the schools *medium rei*; that which is equally distant from each extreme, or which exceeds the lesser extreme as much as it is exceeded by the greater, in respect of quantity, not of proportion; thus 9 is a medium betwixt 6 and 12.

Geometrical MEDIUM, called in the schools *medium personæ*, is that where the same ratio is preserved between the first and second as between the second and third terms, or that which exceeds in the same ratio or quota of itself, as it is exceeded: thus 6 is a geometrical medium metween 4 and 9.

MEDIUM, in *Philosophy*, that space or region through which a body in motion passes to any point: thus æther is supposed to be the medium through which the heavenly bodies move; air, the medium wherein bodies move near our earth; water, the medium wherein fishes live and move; and glass is also a medium of light, as it affords it a free passage. That density or consistency in the parts of the medium, whereby the motion of bodies in it get retarded, is called the *resistance of the medium*; which, together with the force of gravity, is the cause of the cessation of the motion of projectiles.

Subtle or *Æthereal MEDIUM*. Sir Isaac Newton considers it probable, that, beside the particular aërial medium, wherein we live and breathe, there is another more universal one, which he calls an *æthereal medium*; vastly more rare, subtle, elastic, and active, than air, and by that means freely permeating the pores and interstices of all other mediums, and diffusing itself through the whole creation; and by the intervention hereof he thinks it is that most of the great phenomena of nature are effected. See ÆTHER, ELECTRICITY, FIRE, &c.

MEDIUM, in optics, any substance through which light is transmitted.

MEDLAR, see MESPILUS, BOTANY *Index*.

MEDULLA OSSIUM, or *MARROW of the bones*. See ANATOMY, N° 5.

MEDULLA cerebri and *cerebelli*, denotes the white soft part of the brain and cerebellum, covered on the outside with the cortical substance, which is of a more dark or ashy colour. See ANATOMY, N° 131—133.

MEDULLA oblongata, is the medullary part of the brain and cerebellum, joined in one; the fore part of it coming from the brain, and the hind part from the cerebellum. See ANATOMY, N° 134.

It lies on the basis of the skull, and is continued through the great perforation thereof into the hollow of the vertebræ of the neck, back, and loins; though only so much of it retains the name *oblongata* as is included within the skull. After its exit thence it is distinguished by the name of *medulla spinalis*. *Ibid.* N° 135.

MEDUSA, in fabulous history, one of the three Gorgons, daughter of Phorcys and Ceto. She was the only one of the Gorgons who was subject to mortality. She is celebrated for her personal charms and the beauty of her locks. Neptune became enamoured of her, and obtained her favours in the temple of Minerva. This violation of the sanctity of the temple provoked Minerva; and she changed the beautiful locks of Medusa, which had inspired Neptune's love, into serpents, the sight of which turned the beholders into stones: but Perseus, armed with Mercury's axe, with which he killed Argus, cut off Medusa's head, from whose blood sprang Pegasus and Chrysaor, together with the innumerable serpents

serpents that infest Africa. The conqueror placed Medusa's head on the ægis of Minerva, which he had used in his expedition; and the head still retained the same petrifying powers as before.

MEDUSA, a genus of vermes, belonging to the order of mollusca. See HELMINTHOLOGY *Index*.

MEDWAY, a river of England, rises in the Weald of Sussex, and entering Kent near Ashurst, runs by Tunbridge, and thence continues its course towards Maidstone. It is navigable for large ships to Rochester bridge, and thence for vessels and barges to Maidstone, the tide flowing up to that town. The distance between the mouth of this river, where the fort at Sheerness is erected, and Rochester bridge, is between 16 and 18 miles. In this part of the river, the channel is so deep, the banks so soft, and the reaches so short, that it is one of the best and safest harbours in the world; and ships of 80 guns ride afloat at low water, within musket shot of Rochester bridge. Nor is there a single instance upon record, that any of the royal navy ever suffered here by storms, except in the dreadful tempest which happened in November 1703, when the Royal Catherine was sunk and lost. On the shore of this river are two castles, one at Upnor, which guards two reaches of the river, and is supposed to defend all the ships which ride above, between that and the bridge; on the other side of the river is Gillingham castle, built for the same purpose, and well furnished with cannon, which commands the river. Besides these, there is a platform of guns at a place called the Swan, and another at Cockhamwood. But the principal fortification on this river is the castle at Sheerness.

MEEREN, or MEER, JOHN VANDER, called the *Old*, an esteemed painter, was born in 1627. He chose for his subjects sea pieces, landscapes, and views of the sea and its shores; which he painted with great truth, as he had accustomed himself to sketch every scene after nature. The situations of his landscapes are agreeably chosen, frequently they are solemn, and generally pleasing. The forms of his trees are easy and natural, his distances well observed, and the whole scenery has a striking effect, by a happy opposition of his lights and shadows. He also painted battles in an agreeable style, as they showed good composition, were touched with spirit, and had a great deal of transparence in the colouring. He died in 1690.

MEEREN, or MEER, *John Vander*, called *De Jonghe*, an eminent landscape painter, is supposed to have been the son of the old John Vander Meer, and of whom he learned the first rudiments of the art; but being in his youth deprived of his instructor before he had made any great progress, he became a disciple of Nicholas Berghem, and was accounted the best of those who were educated in the school of that admired master. In the manner of his master, he painted landscapes and cattle; and his usual subjects are cottages, with peasants at their rural occupations and diversions. It is observed of him, that he very rarely introduced cows, horses, or any other species of animals, except goats and sheep; the latter of which are so highly finished, that one would imagine the wool might be felt by the softness of its appearance. His touch is scarce perceptible, and yet the colours are admirably united. He died in 1688. The genuine works of this Vander Meer bear a very high price, and are esteemed even in Italy, where they are admitted into the best collections; but the scarcity of them has occasioned many moderate copies after his works to be passed on the undiscerning for real originals.

MEGALE POLIS, in *Ancient Geography*, dividedly (Ptolemy, Pausania); or conjunctly *Megalopolis*, (Strabo): A town of Arcadia, built under the auspices of Epaminondas, after the battle of Leuctra; many inconsiderable towns being joined together in one great city, the better to withstand the Spartans. It was the greatest city of Arcadia, according to Strabo.

MEGALESIA, and MEGALENSES LUDI, feasts and games in honour of Cybele or Rhea the mother of the gods, kept on the 12th of April by the Romans, and famous for great rejoicings and diversions of various sorts. The Galli carried the image of the goddess along the city, with sound of drums and other music, in imitation of the noise they made to prevent Saturn from hearing the cries of his infant son Jupiter, when he was disposed to devour him.

MEGARA, in *Ancient Geography*, a noble city, and the capital of the territory of Megaris, which for many years carried on war with the Corinthians and Athenians. It had for some time a school of philosophers, called the *Megarici*, successors of Euclid the Socratic, a native of Megara. Their dialect was the Doric; changed from the Attic, which it formerly had been, because of Peloponnesian colonists who settled there.

Megara was situated at a distance from the sea, about midway between Athens and Corinth. Its port was called *Nisæa*, from Nisus son of Pandion the second, who obtained Megaris for his portion, when the kingdom of Athens was divided into four lots by his father. He founded the town, which was eighteen stadia or two miles and a quarter from the city, but united with it, as the Piræus with Athens, by long walls. It had a temple of Ceres. "The roof (says Pausanias) may be supposed to have fallen through age." The site (as Dr Chandler informs us*) is now covered with rubbish, among which are standing some ruinous churches. The place has been named from them *Dode Ecclesiais*, "The Twelve Churches;" but the number is reduced to seven. The acropolis or citadel, called also *Nisæa*, was on a rock by the sea side. Some pieces of the wall remain, and a modern fortress has been erected on it, and also on a lesser rock near it.

* *Travels in Greece*, p. 192.

The village Megara (continues the doctor) consists of low mean cottages pleasantly situated on the slope of a brow or eminence indented in the middle. On each side of this vale was an acropolis or citadel; one named Caria; the other from Alcathous, the builder of the wall. They related, that he was assisted by Apollo, who laid his harp aside on a stone, which, as Pausanias testifies, if struck with a pebble returned a musical sound. An angle of the wall of one citadel is seen by a windmill. The masonry is of the species called Incertum. In 1676 the city wall was not entirely demolished, but comprehended the two summits, on which are some churches, with a portion of the plain toward the south. The whole site, except the hills, was now green with corn, and marked by many heaps of stones, the collected rubbish of buildings. A few inscriptions are found, with pedestals fixed in the walls and inverted; and also some maimed or mutilated

mutilated statues. One of the former relates to Atticus Herodes, and is on a pedestal which supported a statue erected to him when consul, A. D. 143. by the council and people of Megara, in return for his benefactions and good will toward the city. In the plain behind the summits, on one of which was a temple of Minerva, is a large basin of water, with scattered fragments of marble, the remains of a bath or of a fountain, which is recorded as in the city, and remarkable for its size and ornaments, and for the number of its columns. The spring was named from the local nymphs called Sithnides.

The stone of Megara was of a kind not discovered any where else in Hellas; very white, uncommonly soft, and consisting entirely of cockle shells. This was chiefly used; and, not being durable, may be reckoned among the causes of the desolation at Megara, which is so complete, that one searches in vain for vestiges of the many public edifices, temples, and sepulchres, which once adorned the city.

Megara was engaged in various wars with Athens and Corinth, and experienced many vicissitudes of fortune. It was the only one of the Greek cities which did not reflourish under their common benefactor Hadrian; and the reason assigned is, that the avenging anger of the gods pursued the people for their impiety in killing Anthemocritus, a herald, who had been sent to them in the time of Pericles. The Athenian generals were sworn on his account to invade them twice a-year. Hadrian and Atticus were followed by another friend, whose memory is preserved by an inscription on a stone lying near a church in the village:— "This too is the work of the most magnificent count Diogenes son of Archelaus, who regarding the Grecian cities as his own family, has bestowed on that of the Megarensians one hundred pieces of gold towards the building of their towers, and also one hundred and fifty more, with two thousand two hundred feet of marble toward re-edifying the bath; deeming nothing more honourable than to do good to the Greeks, and to restore their cities." This person is not quite unnoticed in history. He was one of the generals employed by the emperor Anastasius on a rebellion in Isauria. He surprised the capital Claudiopolis, and sustained a siege with great bravery, A. D. 494.

Megara retains its original name. It has been much infested by corsairs; and in 1676 the inhabitants were accustomed, on seeing a boat approach in the day time or hearing their dogs bark at night, immediately to secrete their effects and run away. The vaiwode or Turkish governor, who resided in a forsaken tower above the village, was once carried off. It is no wonder, therefore, that Nisæa has been long abandoned. The place was burned by the Venetians in 1687.

Megara, in *Ancient Geography*, formerly called *Hybla*, a town towards the east coast of Sicily; extinct in Strabo's time, though the name Hybla remained on account of the excellence of its honey. It was a colony of Megareans from Greece. *Risus Megaricus* denotes a horse laugh.

MEGARIS, in *Ancient Geography*, the country of the Megareans, is described as a rough region, like Attica; the mountain called *Oncian* or the Asinine, now *Macriplayi* or "the long Mountain," extending through it towards Bœotia and Mount Cithæron. It belonged to Ionia or Attica, until it was taken by the Peloponnesians in the reign of Codrus, when a colony of Dorians settled in it. This territory had Attica to the east, Bœotia to the north and west, and the isthmus of Corinth to the south.

Megaris, a small island in the Tuscan sea, joined to Naples by a bridge, now called *Castello dell' Ovo.*

MEGASTHENES, a Greek historian in the age of Seleucus Nicanor, about 300 years before Christ. He wrote about the oriental nations, and particularly the Indians. His history is often quoted by the ancients. What now passes as his composition is spurious.

MEGIDDO, in *Ancient Geography*, a town of Galilee, recited (Joshua xvii. 11.) among the cities of Manasseh, in the tribe of Issachar or Asser, on the west side of Jordan; famous for the defeat of Ahaziah and Josiah, who perished there (2 Kings xxiii. 29.): near it was an open plain, fit for drawing up an army in battle array. It was situated to the north, contrary to its position in the common maps. The Canaanites, being tributary to the Israelites, dwelt in it, Joshua xvii.— It was rebuilt by Solomon, 1 Kings ix.

MEIBOMIUS, the name of several learned Germans.—*John Henry Meibomius* was professor of physic at Helmstadt, where he was born, and at Lubec; he wrote the Life of Mæcenas, published at Leyden in 4to, 1653, with several other learned works. *Henry*, his son, was born at Lubec in 1638; became professor of physic at Helmstadt; and, besides works in his own profession, published *Scriptores rerum Germanicarum*, 3 vols. folio, 1688; a very useful collection, first begun by his father.—*Marcus Meibomius*, of the same family, published a collection of seven Greek authors who had written upon ancient music, with a Latin version by himself, dedicated to Queen Christina of Sweden, who invited him to her court. But she engaging him one day to sing an air of ancient music, while somebody was ordered to dance to it, the immoderate mirth which this occasioned in the spectators so disgusted him, that he immediately left the court of Sweden. His edition of the Greek mythologists, and notes upon Diogenes Laërtius in Menage's edition, show him to have been a man of learning; but he suffered no little raillery for his attempt to correct the Hebrew text of the Bible, by a kind of metre he fancied he had found out in those ancient writings.

MEISSEN, a considerable town of Germany, in the electorate of Saxony, and in the margravate of Misnia, with a castle It formerly belonged to the bishop, but is now secularized, and the inhabitants are Lutherans. In this place is a famous manufactory of porcelain. E. Long. 13. 27. N. Lat. 51. 19.

MEL, Honey, in the *Materia Medica*. See Honey.

MELA, Pomponius, an ancient Latin writer, was born in the province of Bætica in Spain, and flourished in the reign of the emperor Claudius. His three books of Cosmography, or *De situ orbis*, are written in a concise, perspicuous, and elegant manner; and have been thought worthy of the attention and labours of the ablest critics. Isaac Vossius gave an edition of them in 1658, 4to, with very large and copious notes. To this edition is added, *Julii Honorii oratoris excerptum cosmographiæ*, first published from the manuscript; and

and *Æthici cosmographia*. Gronovius afterwards published another edition with illustrations by medals. In his last edition are added five books, *De Geographia*, written by some later author; by Jornandes, as Fabricius conjectures.

MELÆNE, or Black Flux, in *Medicine*. See Medicine, N° 409.

MELALEUCA, a genus of plants belonging to the polydelphia class. See Botany *Index*.

MELAMPODIUM, a name given to black hellebore. See Helleborus, Botany *Index*.

Melampodium, a genus of plants belonging to the syngenesia class; and in the natural method ranking under the 49th order, *Compositæ*. See Botany *Index*.

MELAMPUS, in fabulous history, a celebrated soothsayer and physician of Argos, son of Amythaon and Idomenea or Dorippe. He lived at Pylos in Peloponnesus. His servants once killed two large serpents who had made their nests at the bottom of a large oak; and Melampus paid so much regard to their remains, that he raised a burning pile and burned them upon it. He also took particular care of their young ones, and fed them with milk. Some time after this, the young serpents crept to Melampus as he slept on the grass near the oak; and, as if sensible of the favours of their benefactor, they wantonly played around him, and softly licked his ears. This awoke Melampus, who was astonished at the sudden change which his senses had undergone. He found himself acquainted with the chirping of the birds, and with all their rude notes, as they flew around him. He took advantage of this supernatural gift, and soon made himself perfect in the knowledge of futurity, and Apollo also instructed him in the art of medicine. He had soon after the happiness of curing the daughters of Prœtus, by giving them hellebore, which from that circumstance has been called *melampodium*; and, as a reward for his trouble, he married the eldest of these princesses. The tyranny of his uncle Neleus, king of Pylos, obliged him to leave his native country; and Prœtus, to show himself more sensible of his services, gave him part of his kingdom. About this time the personal charms of Pero, the daughter of Neleus, had gained many admirers; but the father promised his daughter only to him who brought into his hands the oxen of Iphiclus. This condition displeased many; but Bias, who was also one of her admirers, engaged his brother Melampus to steal the oxen and deliver them to him. Melampus was caught in the attempt, and imprisoned; and nothing but his services as a soothsayer and physician to Iphiclus would have saved him from death. All this pleaded in the favour of Melampus; but when he had taught the childless Iphiclus how to become a father, he not only obtained his liberty, but also the oxen; and with them he compelled Neleus to give Pero in marriage to Bias. A severe distemper, which had rendered the women of Argos insane, was totally removed by Melampus; and Anaxagoras, who then sat on the throne, rewarded his merit by giving him part of his kingdom, where he established himself, and where his posterity reigned during six successive generations. He received divine honours after death, and temples were raised to his memory.

MELAMPYRUM, Cow-wheat, a genus of plants belonging to the didynamia class; and in the natural method ranking under the 40th order, *Personatæ*. See Botany *Index*.

MELANCHOLY, a kind of delirium attended with gloomy thoughts, heaviness, and sorrow. See Medicine, N° 327.

MELANCTHON, Philip, born at Bretten in the Palatinate in 1495, was one of the wisest and most able men of his age among the reformers, though of a mild temper, and disposed to accommodate rather than to inflame disputes. In his youth he made an admirable progress in learning, and was made Greek professor at Wittenberg in 1509. Here his lectures upon Homer and the Greek text of St Paul's Epistle to Titus, drew to him a great number of auditors, and entirely effaced the contempt to which his low stature and mean appearance had exposed him. Melancthon reduced the sciences to systems; and acquired such reputation, that he had sometimes 2500 auditors. He soon entered into an intimate friendship with Luther, who taught divinity in the same university; and in 1519 they went together to Leipsic, to dispute with Eccius. The following years he was continually engaged in various employments; he composed several books; he taught divinity; took several journeys, in order to found colleges and visit churches; and in 1530 drew up a confession of faith, which goes by the name of the *Confession of Augsburg*, because it was presented to the emperor at the diet held in that city. All Europe was convinced that he was not, like Luther, backward to accommodate the differences between the various sects of Christians. He hated religious disputes, and was drawn into them only through the necessity of the part he was called to act in the world; and therefore would have sacrificed many things to have produced an union among the Protestants. For this reason, Francis I. the French king, wrote to desire him to come and confer with the doctors of the Sorbonne, in order to agree with them about putting an end to all controversies; but though Luther endeavoured to persuade the elector of Saxony to consent to that journey, and though Melancthon himself desired it, that prince, whether he distrusted Melancthon's moderation, or was afraid of quarrelling with the emperor Charles V. would never grant his permission. The king of England also in vain desired to see him. Melancthon, in 1529, assisted at the conferences of Spires. In 1541, he was at the famous conferences at Ratisbon. In 1543, he went to meet the archbishop of Cologne to assist him in introducing the reformation into his diocese; but that project came to nothing: and in 1548, he assisted at seven conferences on the subject of the interim of Charles V. and wrote a censure on that interim, and all the writings presented at these conferences. He was extremely affected at the dissensions raised by Flaccus Illyricus. His last conference with those of the Roman communion was at Worms, in 1557. He died at Wittenberg in 1560, and was interred near Luther. Some days before he died, he wrote upon a piece of paper the reasons which made him look upon death as a happiness; that the chief of them was, that it "delivered him from theological persecutions." Nature had given Melancthon a peaceable temper, which was but ill suited to the time he was to live in. His moderation served only to be his cross. He was like a lamb in the midst of wolves. Nobody liked his mildness; it looked as if he was

was lukewarm; and even Luther himself was sometimes angry at it.

Melancthon was a man in whom many good as well as great qualities were wonderfully united. He had great parts, great learning, great sweetness of temper, moderation, contentedness, and the like, which would have made him very happy in any other times but those in which he lived. He never affected dignities, or honours, or riches, but was rather negligent of all these things; too much so in the opinion of some, considering he had a family; and his son-in-law Sabinus, who was of a more ambitious temper, was actually at variance with him upon this very account. Learning was infinitely obliged to him on many accounts: on none more than this, that, as already observed, he reduced almost all the sciences which had been taught before in a vague irregular manner into systems. Considering the distractions of his life, and the infinity of disputes and tumults in which he was engaged, it is astonishing how he could find leisure to write so many books. Their number is prodigious, insomuch that it was thought necessary to publish a chronological catalogue of them in the year 1582. His works indeed are not correct, and he himself owned it: but as he found them useful, he chose rather to print a great number, than to finish only a few: "which however (as Bayle says), was postponing his own glory to the advantage of others." His constitution was very weak, and required great tenderness and management; which made Luther, as hot and zealous as he was, blame him for labouring too earnestly in the vineyard.

MELANIPPIDES, in fabulous history, a Greek poet about 520 years before Christ. His grandson of the same name, flourished about 60 years after at the court of Perdiccas the Second, of Macedonia. Some fragments of their poetry are still extant.

MELANTERIA, an old term in *Natural History*, which seems to have been applied to copper pyrites.

The Greeks used it externally as a gentle escharotic and a styptic, as an ingredient in their ointments for old ulcers, and also to sprinkle in the form of powder on fresh wounds, in order to stop the hæmorrhage.

MELASSES. See MOLASSES.

MELASTOMA, the AMERICAN GOOSEBERRY-TREE, a genus of plants belonging to the decandria class; and in the natural method ranking under the 17th order, *Calycanthemæ*. See BOTANY *Index*.

MELCHA, a small village of Barbary, situated about 30 miles from the city of Tunis, built on the ruins of Carthage, some of which are still visible.

MELCHITES, in church history, the name given to the Syriac, Egyptian, and other Christians of the Levant. The Melchites, excepting some few points of little or no importance, which relate only to ceremonies and ecclesiastical discipline, are in every respect professed Greeks; but they are governed by a particular patriarch, who resides at Damas, and assumes the title of *patriarch of Antioch*. They celebrate mass in the Arabian language. The religious among the Melchites follow the rule of St Basil, the common rule of all the Greek monks. They have four fine convents distant about a day's journey from Damas, and never go out of the cloister.

MELCHISEDEC, or MELCHIZEDEK, king of Salem, and priest of the Most High. The scripture tells us nothing either of his father, or of his mother, or of his genealogy, or of his birth, or of his death. And in this sense he was a figure of Jesus Christ, as St Paul affirms, who is a priest for ever, according to the order of Melchisedec, and not according to the order of Aaron, whose original, life, and death, are known. When Abraham returned from pursuing the four confederate kings, who had defeated the kings of Sodom and Gomorrah, and had taken away Lot, Abraham's nephew, along with them (Gen. xiv. 17, 18, 19, &c.), Melchisedec came to meet Abraham as far as the valley of Shaveh, who was afterwards named the King's valley, presented him with the refreshment of bread and wine (or he offered bread and wine in sacrifice to the Lord, for he was a priest of the most high God), and blessed him. Abraham being desirous to acknowledge in him the quality of priest of the Lord, offered him the tythes of all he had taken from the enemy. After this time, there is no mention made of the person of Melchisedec: only the Psalmist (cx. 4.) speaking of the Messiah, says, "Thou art a priest for ever after the order of Melchisedec." St Paul, in his epistle to the Hebrews, unfolds the mystery which is concealed in what is said of Melchisedec in the Old Testament. See Heb. v. 6—10. An infinite number of difficulties and scruples have been started on the subject of Melchisedec.—St Jerome thought that Salem, of which Melchisedec was king, was not Jerusalem, but the city of Salem near Scythopolis, where they still pretended to show the ruins of the palace of this prince. The greatness and extent of these ruins are a sufficient proof of the magnificence of this ancient building. He thinks it was at this city of Salem or Shalem, that Jacob arrived after his passage over Jordan, at his return from Mesopotamia (Gen. xxxiii. 18.). Some believe that Salem, where Melchisedec reigned, is the same as Salim spoken of in the gospel of St John, chap. iii. 23. From the time of Epiphanes, there were names invented for the father and mother of Melchisedec. To his father was given the name of Heraclas or Heracles, and to his mother that of Ashtaroth or Astaria. It is generally agreed on by the learned, that when the apostle says, he was "without father and without mother," no more is meant, than that he is introduced into the history of Abraham without acquainting us who he was, or whence he came, where he lived or when he died. Nevertheless, some have taken St Paul's words literally, and contended that he was not of human but divine nature. Origen and Didymus took him to be an angel; and the author of the Questions upon the Old and New Testaments pretends, that he was the Holy Ghost, who appeared to Abraham in a human form. The Arabic Catena upon the ninth chapter of Genesis, makes Melchisedec to be descended from Shem by his father, and from Japheth by his mother. Heraclas or Heraclim his father, was, they say, son or grandson of Phaleg, and son of Heber; and his mother, named Salathiel, was daughter of Gomer son of Japheth. Cedrenus and others derive Melchisedec from an Egyptian stock. They say his father was called Sidon or Sida, and was the founder of the city of Sidon, the capital of Phœnicia. Suidas says he was of the cursed race of Canaan; for which reason the scripture does not mention his genealogy. The Jews and Samaritans believed Melchisedec to be the same

same with the patriarch Shem; which opinion has been followed by a great number of modern writers. M. Jurieu has undertaken to prove that he is the same as Cham or Ham. It would be endless to set down all the opinions upon this matter: therefore we shall only add, that Peter Cunæus and Peter du Moulin have asserted, that Melchisedec who appeared to Abraham was the Son of God, and that the patriarch worshipped him and acknowledged him for the Messiah.

About the beginning of the third century arose the heresy of the Melchisedecians, who affirmed that Melchisedec was not a man, but a heavenly power, superior to Jesus Christ: for Melchisedec, they said, was the intercessor and mediator of the angels, but Jesus Christ was so only for men, and his priesthood only a copy of that of Melchisedec, who was the Holy Ghost.

We shall only beg leave to add here one opinion more concerning Melchisedec, which is that of the learned Heidegger, who, as the author of the *Hist. Patriar.* thinks, has taken the right method of explaining the accounts of Moses and the apostle Paul relating to this extraordinary person. He supposes a twofold Melchisedec; the one historical, whereof Moses gives an account in the 14th chapter of Genesis, as that he was king as well as high priest of Jerusalem; the other allegorical, whom St Paul describes, and this allegorical person is Jesus Christ.

As the history of this prince and priest is so little known, it is no wonder, as Selden observes, that many fabulous accounts have been invented of him; of which the following may suffice as a specimen. Eutychus patriarch of Alexandria relates, that the body of Adam having been embalmed according to his order, was deposited in a cave under a mountain of the children of Seth; but that Adam before his death had commanded that they should take away his remains from that place, and transport them to the middle of the earth: that Noah, to follow the orders of his ancestors, had preserved the bodies of Adam and all the patriarchs with him in the ark: that finding himself near his death, he ordered his son Shem to take the body of Adam, to furnish himself with bread and wine for his journey, to take with him Melchisedec the son of Phaleg, and to go to the place in which an angel would show them where to bury the first man: that Noah added this order, "Command Melchisedec to fix his residence in that place, and to live unmarried all his lifetime, because God has chosen him to do service in his presence; command him, that he build no temple, nor shed the blood of birds, nor four-footed beasts, or any other animal; and that he offer no other oblations to God but bread and wine." This is the reason, according to this author, why Melchisedec, when he met Abraham, brought forth only bread and wine.

A Greek author, under the name of Athanasius, relates, that Melchisedec was the son of an idolatrous king called Melchi and of a queen called Salem.—Melchi, having resolved to offer a sacrifice to the gods, sent his son Melchisedec to fetch him seven calves. In the way the young prince was enlightened by God, and immediately returned to his father, to demonstrate to him the vanity of his idols. Melchi, in wrath, sent him back to fetch the victims. While he was absent, the king sacrificed his eldest son, and a great many other children, to his gods. Melchisedec returning, and conceiving great horror at this butchery, retired to Mount Tabor, where he lived seven years, without clothes, and fed only on wild fruits. At the end of seven years, God appeared to Abraham, bid him go up to Mount Tabor, where he should find Melchisedec. He ordered him to clothe him, and to ask his blessing; which Abraham having done, Melchisedec anointed him with oil, and they came down together from the mountain.

Melchisedec, Melcomb-regis.

MELCOMB-REGIS, a town of Dorsetshire, in England, 130 miles from London, is situated at the mouth of the river Wey, by which it is parted from Weymouth. It appears from the name to have been anciently the king's demesne, and from the records to have paid quit-rent to the crown all along after King Edward I. till it was bought off by the inhabitants before they were united to Weymouth. It lies on the north side of the haven, on a peninsula surrounded by the sea on all sides except on the north. The streets are broad and well paved, and many of the houses large and high. It sent members to parliament in the reign of King Edward I. before Weymouth had that privilege. It was by parliament appointed a staple in the reign of Edward III. In the next reign the French burnt it; and it was thereby rendered so desolate, that the remaining inhabitants prayed and obtained a discharge from customs. On account of its quarrels with Weymouth, in the reign of Henry VI. its privileges as a port were removed to Pool: but in that of Queen Elizabeth they were restored to it by act of parliament, which was confirmed in the next reign, on condition that Melcomb and Weymouth should make but one corporation, and enjoy their privileges in common; and to this was owing the flourishing state of both. In the two reigns last mentioned, a wooden bridge with seventeen arches was built from hence to Weymouth; to which, as well as its church, the chief contributors were certain citizens of London; and upon its decay it was rebuilt in 1770. Here is a good market place and town-hall, to which the members of the corporation of Weymouth come to attend public business, as the inhabitants do to its church for public worship. For several years past the sea has retired from it on the east, the priory formerly being bounded by the sea; but there is now a street beyond it, from which it is several paces to the high water mark. The priory was situated in the east part of the town, in Maiden street, whose site occupied about an acre, now covered with tenements. On the south side are the remains of the chapel, now converted into a malt house. Near it are the remains of an ancient building, formerly a nunnery. Here are three meeting houses, and a workhouse for the poor. The church, which is in the middle of the town, has a wooden turret for a bell, and had been an old chapel. It was rebuilt in 1605, and made parochial, and is a handsome fabric, with a beautiful altarpiece painted and given by Sir James Thornhill. The port, which generally goes by the name of Weymouth, is said to be the best frequented in the county, and is defended by Sandford and Portland castles. The markets for both towns are Tuesdays and Fridays, but there are no fairs. In 1811 Melcomb contained 2985 inhabitants, Weymouth 1747. They are now one corporation and borough, consisting of a mayor, recorder, two bailiffs, an uncertain number of aldermen, and twenty-four capital burgesses. Whoever has been a mayor is ever after an alderman. They send four burgesses to Parliament, who are elected by such as have freeholds, whether they are inhabitants or not; the num- of voters is near 700. Every elector, as in London, has the privilege of voting for four persons, who, when chosen, are returned, in two distinct indentures, as the burgesses of Weymouth and the burgesses of Melcomb-regis.

MELDÆ, in *Ancient Geography*, a town of Gallia Celtica, (called *Meldorum Civitas* in the Notitia), on the Matrona. Now *Meaux*, a city of Champagne, on the Marne, in France.

MELEAGER, in fabulous history, a celebrated hero, son of Oeneus king of Calydonia, by Althæa, daughter of Thestius. The Parcæ were present at the moment of his birth, and predicted his future greatness. Clotho said that he would be brave and courageous; Lachesis foretold his uncommon strength and valour; and Atropos said that he should live as long as that firebrand, which was on the fire, remained entire and unconsumed. Althæa no sooner heard this, than she snatched the stick from the fire, and kept it with the most jealous care, as the life of her son totally depended upon its preservation. The fame of Meleager increased with his years: he signalized himself in the Argonautic expedition, and afterwards delivered his country from the neighbouring inhabitants, who made war against his father at the instigation of Diana, whose altars Oeneus had neglected. But Diana punished the negligence of Oeneus by a greater calamity. She sent a huge wild boar, which laid waste all the country, and seemed invincible on account of its immense size. It became soon a public concern: all the neighbouring princes assembled to destroy this terrible animal: and nothing is more famous in mythological history, than the hunting of the Calydonian boar. The princes and chiefs that assembled, and which are mentioned by mythologists, were Meleager son of Oeneus, Idas and Lynceus sons of Apharcus, Dryas son of Mars, Castor and Pollux sons of Jupiter and Leda, Pirithous son of Ixion, Theseus son of Ægeus, Anceus and Cepheus sons of Lycurgus, Admetus son of Pheres, Jason of Æson, Peleus and Telamon sons of Æacus, Iphicles son of Amphitryon, Eurytrion son of Actor, Atalanta daughter of Schœneus, Iolas the friend of Hercules, the sons of Thestius, Amphiaraus son of Oileus, Protheus, Cometes, the brothers of Althæa Hippothous son of Cercyon, Leucippus, Adrastus, Ceneus, Phileus, Echion, Lelex, Phœnix son of Amyntor, Panopeus, Hyleus, Hippasus, Nestor, Menœtius the father of Patroclus, Amphicides, Laërtes the father of Ulysses, and the four sons of Hippocoon. This troop of armed men attacked the boar, and it was at last killed by Meleager.—The conqueror gave the skin and the head to Atalanta, who had first wounded the animal. This irritated the rest, and particularly Toxeus and Plexippus the brothers of Althæa, and they endeavoured to rob Atalanta of the honourable present. Meleager defended her, and killed his uncles in the attempt. Meantime the news of this celebrated conquest had already reached Calydon, and Althæa went to the temple of the gods to return thanks for the victory which her son had gained: But being informed that her brothers had been killed by Meleager, she in a moment of resentment threw into the fire the fatal stick on which her son's life depended, and Meleager died as soon as it was consumed. Homer does not mention the firebrand; whence some have imagined that this fable is posterior to that poet's age. But he says, that the death of Toxeus and Plexippus so irritated Althæa, that she uttered the most horrible curses and imprecations upon her son's head.

MELEAGER, a Greek poet, the son of Eucrates, was born at Seleucia in Syria, and flourished under the reign of Seleucus VI. the last king of Syria. He was educated at Tyre; and died in the island of Coos, anciently called Merope. He there composed the Greek epigrams called by us the *Anthologia*. The disposition of the epigrams in this collection was often changed afterwards, and many additions have been made to them. The monk Planudes put them into the order they are in at present, in the 1380.

MELEAGRIS, the TURKEY; a genus of birds belonging to the order of gallinæ. See ORNITHOLOGY *Index*.

MELES, the BADGER. See URSUS, MAMMALIA *Index*.

MELES, in *Ancient Geography*, a fine river running by the walls of Smyrna in Ionia, with a cave at its head, where Homer is said to have written his poems. And from it Homer takes his original name *Melesigenes*, given him by his mother Critheis, as being born on its banks. (Herodotus).

MELETIANS, in ecclesiastical history, the name of a considerable party who adhered to the cause of Meletius bishop of Lycopolis, in Upper Egypt, after he was deposed, about the year 306, by Peter bishop of Alexandria, under the charge of his having sacrificed to the gods, and having been guilty of other heinous crimes; though Epiphanius makes his only failing to have been an excessive severity against the lapsed. This dispute, which was at first a personal difference between Meletius and Peter, became a religious controversy; and the Meletian party subsisted in the fifth century, but was condemned by the first council of Nice.

MELIA, AZADERACH, or the *Bead Tree*, a genus of plants, belonging to the decandria class; and in the natural method ranking under the 23d order, *Trihilatæ*. See BOTANY *Index*.

MELIANTHUS, HONEY-FLOWER, a genus of plants belonging to the didynamia class; and in the natural method ranking under the 24th order, *Corydales*. See BOTANY *Index*.

MELIBOEA, in *Ancient Geography*, an island of Syria, at the mouth of the Orontes; which before it falls into the sea, forms a spreading lake round it. This island was famous for its purple dye. Thought to be a colony of Thessalians; and hence Lucretius's epithet, *Thessalicus*.

MELICA, ROPEGRASS, a genus of the digynia order, belonging to the triandria class of plants; and in the natural method ranking under the 4th order, *Gramina*. See BOTANY *Index*.

MELICERES, in *Surgery*, a kind of encysted tumour,

mour, so called when their contents are of the consistence of honey. See TUMOUR, SURGERY *Index*.

MELICERTA, MELICERTES, or *Melicertus*, in fabulous history, a son of Athamas and Ino. He was saved by his mother from the fury of his father, who prepared to dash him against a wall as he had done his brother Learchus. The mother was so terrified that she threw herself into the sea with Melicerta in her arms. Neptune had compassion on the misfortunes of Ino and her son. He changed them both into sea deities. Ino was called *Leucothoë* or *Matuta;* and Melicerta was known among the Greeks by the name of *Palæmon*, and among the Latins by that of *Portumnus*. Some suppose that the Isthmian games were instituted in honour of Melicerta.

MELILLA, an ancient town of Africa, in the kingdom of Fez, and in the province of Garet. It was taken by the Spaniards in 1469, but returned back to the Moors. W. Long. 2. 9. N. Lat. 35. 20.

MELILOT. See TRIFOLIUM, BOTANY and AGRICULTURE *Index*.

MELINDA, a kingdom on the east coast of Africa, situated, according to some, between the third and fourth degree of south latitude; though there is great disagreement among geographers as to its extent. It is allowed by all, however, that the coasts are very dangerous; being full of rocks and shelves, and the sea at some seasons very liable to tempests. The kingdom of Melinda is for the most part rich and fertile; producing almost all the necessaries of life except wheat and rice, both which are brought thither from Cambaya and other parts; and those who cannot purchase them make use of potatoes in their stead, which are here fine, large, and in great plenty. They likewise abound with great variety of fruit trees, roots, plants, and other esculents, and with melons of exquisite taste. They have also great plenty of venison, game, oxen, sheep, hens, geese, and other poultry, &c. and one breed of sheep whose tails weigh between 30 and 40 pounds. The capital city is also called *Melinda*.

MELINUM, in *Natural History*, the name of an earth famous in the earliest ages of painting, being the only white of the great painters of antiquity; and, according to Pliny's account, one of the three colours with which alone they performed all their works. From the description given of this earth it seems to be aluminous, tolerably pure, and in a state of minute division.

MELISSA, in fabulous history, a daughter of Melissus king of Crete, who with her sister Amalthæa fed Jupiter with the milk of goats. She first found out the means of collecting honey; whence it has been fabled that she was changed into a bee, as her name is the Greek word for that insect.

MELISSA, *Baum*, a genus of plants, belonging to the didynamia class; and in the natural method ranking under the 42d order *Verticillatæ*. See BOTANY *Index*.

MELISSUS of SAMOS, a Greek philosopher, was the son of Rhagines and the disciple of Parmenides; and lived about 440 B. C. He pretended that the universe is infinite, immoveable, and without a vacuum. Themistocles was among his pupils.

MELITE, in *Ancient Geography*, an island referred to Africa by Scylax and Ptolemy; but nearer Sicily, and allotted to it by the Romans: commended for its commodious harbours; for a city well built, with artificers of every kind, especially weavers of fine linen; all owing to the Phœnicians, the first colonists. Now *Malta;* remarkable for St Paul's shipwreck. See MALTA.

MELITE, *Melita*, or *Melitina Insula;* an island on the coast of Illyricum in the Adriatic. The *Catuli Melitæi* (Pliny) were famous. Now *Melede*, the name of the island Samos. See SAMOS.

MELITE, in *Ancient Geography*, a town of Ionia, struck out of the number of Ionian towns on account of the arrogance of the people, and Smyrna admitted in lieu of it. The situation is not specified.

MELITENSIS TERRA, the *Earth of Malta:* an earth of which there are two very different kinds; the one of which is a bole, the other a marl. The latter is that known by medical authors under this name; the former is the Malta earth now in use; but both being brought from the same place, are confusedly called by the same name. The Maltese marl, which is the *terra Melitensis* of medical authors, is a loose, crumbly, and light earth, of an unequal and irregular texture; and, when exposed to the weather, soon falls into fine soft powder: but when preserved and dried, it becomes a loose, light mass, of a dirty white colour, with a grayish cast: it is rough to the touch, adheres firmly to the tongue, is very easily crumbled to powder between the fingers, and stains the hands. Thrown into the water, it swells, and afterwards moulders away into a fine powder. It ferments very violently with acids. Both kinds are found in great abundance in the island of Malta, and the latter has been much esteemed as a remedy against the bites of venomous animals. The other has supplied its place in the German shops; and is used there as a cordial, sudorific, and astringent.

MELITO (canonized), bishop of Sardis in Lydia, in the second century; remarkable for the apology he presented to the emperor Aurelius, in favour of the Christians; on which Eusebius and the other ancient ecclesiastical writers bestow great praises: but that apology and all Melito's other works are lost.

MELITUS, a Greek orator and poet, the accuser of Socrates. The Athenians, after the death of Socrates, discovering the iniquity of the sentence they had passed against that great philosopher, put Melitus to death, 400 B. C.

MELLER, a lake of Sweden, 80 miles long, and 30 broad; on which stands the city of Stockholm.

MELLI, with the country of the Mundingoes, in Africa. The country formerly called *Melli*, now chiefly inhabited by the Mundingoes, who still retain pretty much of the character ascribed to the people of Melli, lies to the south of the river Gambia; on the west it borders on the kingdom of Kabo; on the south it has *Melli*, properly so called, and the mountains that part it from Guinea; and on the east it extends to the kingdom of Gago. With a great part of this country we are little acquainted, as is the case with regard to most of the inland territories of Africa; but towards the sea coast this country is a little better known.

The first place of note we meet with is Kachao, a Portuguese colony, situated on the river of St Domingo, which falls into the sea about 26 leagues below this town.—About 26 leagues above Kachao, on the same

same side of the river, is another trading town called *Farini*, where, in the months of October and November, there is some trade in wax and ivory.—Bot is a village near the mouth of the river Gesves, where most of the traders buy rice; which is in great plenty there, and very good.—Gesves is a village on a river of the same name, on which the Portuguese have a factory. At Gesves one may trade yearly for 250 slaves, 80 or 100 quintals of wax, and as many of ivory. Near the mouth of the river of Gesves is a village called *Kurbali*, where there is a considerable trade for salt; here are also some slaves and ivory. Rio Grande, or the Great River, runs about 10 or 12 leagues to the south of the river of Gesves. About 80 leagues from the mouth of it is a nation of negroes, who are considerable traders in ivory, rice, millet, and some slaves. They are called *Analons*. Over against the mouth of Rio Grande is a cluster of islands called *Bissago Isles*; the most considerable of which is Cassagut, being about six leagues long and two broad; its soil is very good, and produces millet, rice, and all kinds of pulse, besides orange and palm trees, and many others. This island, with those of Carache, Canabac, and La Gallina, are the only ones where the Europeans may trade with some security. They trade, however, sometimes at the other islands, but they must be extremely cautious; and yet after all their precautions, they will be robbed and murdered if they venture to go ashore. The river Nunho runs 16 leagues to the south of Rio Grande; it is very considerable, and comes from a vast distance inland. One may buy here 300 quintals of ivory and 100 slaves a-year. Rice grows here admirably well, and is very cheap. There are everywhere sugar canes which grow naturally; and plants of indigo, which might turn to good account. The trade is carried on here from March till August. In the river of Sierra Leone, the late Royal African Company of England had, in the year 1728, two islands; the one, called *Tasso*, a large flat island, near three leagues in circumference, on which the company's slaves had a good plantation; the rest of the island is covered with wood, among which are silk cotton trees of an unaccountable size. The other island is *Bense*, whereon stood a regular fort. It was formerly the residence of one of the English chiefs.

MELLITE, or Honey-stone, a mineral substance, composed of a peculiar acid and alumina. See Mellite, Mineralogy *Index*.

MELMOTH, William, Esq. a learned member of Lincoln's Inn, was born in 1666. In conjunction with Mr Peere Williams, Mr Melmoth was the publisher of Vernon's Reports, under an order of the court of chancery. He had once an intention of printing his own Reports; and a short time before his death advertised them at the end of those of his coadjutor Peere Williams, as then actually preparing for the press. They have, however, not yet made their appearance. But the performance for which he justly deserves to be held in perpetual remembrance is, "The Great Importance of a Religious Life;" concerning which it may be mentioned to the credit of the age, that notwithstanding many large editions had before been circulated, 42,000 copies of this useful treatise have been sold in the last 18 years. It is a somewhat singular circumstance, that the real author of this most admirable treatise should never before have been publicly known (it having been commonly attributed to the first earl of Egmont, and particularly by Mr Walpole in his Catalogue); which is the more surprising, as the author is plainly pointed out in the following short character prefixed to the book itself: It may add weight, perhaps, to the reflections contained in the following pages, to inform the reader, that the author's life was one uniform exemplar of those precepts which, with so generous a zeal, and such an elegant and affecting simplicity of style, he endeavours to recommend to general practice. He left others to contend for modes of faith, and inflame themselves and the world with endless controversy: it was the wiser purpose of his more ennobled aim, to act up to those clear rules of conduct which revelation hath graciously prescribed. He possessed by temper every moral virtue; by religion every Christian grace. He had a humanity that melted at every distress; a charity which not only thought no evil, but suspected none. He exercised his profession with a skill and integrity which nothing could equal but the disinterested motive that animated his labours, or the amiable modesty which accompanied all his virtues. He employed his industry, not to gratify his own desires; no man indulged himself less: not to accumulate useless wealth; no man more disdained so unworthy a pursuit: it was for the decent advancement of his family, for the generous assistance of his friends, for the ready relief of the indigent. How often did he exert his distinguished abilities, yet refuse the reward of them, in defence of the widow, the fatherless, and him that had none to help him! In a word, few have ever passed a more useful, not one a more blameless life; and his whole time was employed either in doing good, or in meditating it. He died on the 6th day of April 1743, and lies buried under the cloister of Lincoln's Inn Chapel. MEM. PAT. OPT. MER. FIL. DIC." The son, by whom this character is drawn, is William Melmoth, Esq. the celebrated translator of Pliny and of Cicero's Letters; and author of those which pass under the name of *Sir Thomas Fitzosborne*.

MELOCHIA, Jews Mallow, a genus of plants belonging to the monadelphia class; and in the natural method ranking under the 37th order, *Columniferæ*. See Botany *Index*.

MELODUNUM, in *Ancient Geography*, a town of the Cenones in Gallia Celtica, above Lutetia; now *Melun*, in the Isle of France, on the Seine.

MELODY, in music, a succession of sounds ranged in such a manner, according to the laws of rhythmus and modulation, that it may form a sentiment agreeable to the ear. Vocal melody is called *singing*; and that which is performed upon instruments may be termed *symphonic melody*.

The idea of rhythmus necessarily enters into that of melody. An air is not an air but in proportion as the laws of measure and quantity are observed. The same succession of sounds is susceptible of as many different characters, as many different kinds of melody, as the various ways by which its emphatic notes, and the quantities of those which intervene, may be diversified; and the change in duration of the notes alone, may disguise that very succession in such a manner that it cannot be known. Thus, melody in itself is nothing; it is the rhythmus or measure which determines it, and there can be no air without time. If then we abstract measure

Melody. measure from both, we cannot compare melody with harmony; for to the former it is essential, but not at all to the latter.

Melody, according to the manner in which it is considered, has a relation to two different principles. When regarded only as agreeable to the proportions of sound and the rules of modulation, it has its principle in harmony; since it is a harmonical analysis, which exhibits the different gradations of the scale, the chords peculiar to each mode, and the laws of modulation, which are the sole elements that compose an air. According to this principle, the whole power of melody is limited to that of pleasing the ear by agreeable sounds, as the eye may be pleased with an agreeable assemblage of suitable colours. But when considered as an imitative art, by which we may affect the mind with various images, excite different emotions in the heart, inflame or soothe the passions; by which, in a word, we produce different effects upon our moral faculties, which are not to be effectuated by the influence of external sense alone, we must explore another principle for melody: for in our whole internal frame there appears to be no power upon which either harmony alone, or its necessary results, can seize, to affect us in such a manner.

What then is the second principle! It is as much founded on nature as the first; but, in order to discover its foundation in nature, it will require a more accurate though simpler observation, and a more exquisite degree of sensibility in the observer. This principle is the same which varies the tone of the voice, when we speak, according as we are interested in what we say, and according to the different emotions which we feel in expressing it. It is the accent of languages which determines the melody of every nation; it is the accent which determines us to employ the emphasis of speaking while we sing, and to speak with more or less energy according as the language which we use is more or less accented. That language whose accents are the most sensible, ought to produce a more passionate and more lively melody; that which has little accentuation, or none at all, can only produce a cold and languid melody, without character and without expression. These are the true principles: in proportion as we depart from them, when we speak of the power of music upon the human heart, we shall become unintelligible to ourselves and others: our words will be without meaning.

If music does not impress the soul with images but by melody, if from thence it obtains its whole power, it must follow, that all musical sounds which are not pleasing by themselves alone, however agreeable to harmony they may be, is not an imitative music; and, being incapable, even with its most beautiful chords, either to present the images of things, or to excite the finer feelings, very soon cloys the ear, and leaves always the heart in cold indifference. It follows likewise, that notwithstanding the parts which harmony has introduced, and which the present taste of music so wantonly abuses, wherever two different melodies are heard at the same time, they counteract each other, and destroy the effects of both, however beautiful each may be when performed alone: from whence it may be judged with what degree of taste the French composers have introduced in their operas the miserable practice of accompanying one air with another, as well in singing, which is the native expression of pathos and sentiment, as in instrumental performances; which is the same thing as if whimsical orators should take it in their heads to recite two orations at the same time, that the elegance of each might derive more force from the other.

Melody || Melos.

So much for Rousseau. The translator, however, has reason to fear, that the causes by which national melody is diversified and characterized, are more profound and permanent than the mere accentuation of language. This indeed may have great influence in determining the nature of the rhythmus, and the place of emphatic notes; but very little in regulating the nature of the emphasis and expression themselves. If Rousseau's principle be true in its full extent, he must of necessity acknowledge, that an air which was never set or intended for words, however melodious, cannot be imitative; he must likewise confess, that what is imitative in one nation cannot be such in another: nor can it be denied, upon his hypothesis, that the recitative, which is formed upon the mode of speaking, is the most forcible of all melodies; which is absurd. His other observations are at once judicious and profound. Though it is impossible to exhibit the beauty and variety of harmony by playing the same melody at the same time upon different keys, admitting those keys to form among themselves a perfect chord, which will of consequence preserve all the subsequent notes in the same intervals; yet this perfect harmony would by no means be uniformly pleasing to the ear. We must therefore of necessity introduce less perfect chords to vary and increase the pleasure, and these chords in any complex system of music must of necessity produce dissonances. It then becomes the business of the composer to be careful that these discords may arise as naturally from, and return as naturally to perfect harmony as possible. All these causes must inevitably vary the melody of the different parts; but still, amidst all these difficulties, the artist ought to be zealous in preserving the melody of each as homogeneous with the others as possible, that the result of the whole may be in some measure uniform. Otherwise, by counteracting each other, the parts will reciprocally destroy the effects one of another.

MELOE, a genus of insects of the order of coleoptera. See ENTOMOLOGY *Index*.

MELON, a species of CUCUMIS, in the Linnæan system. See BOTANY and GARDENING *Index*.

Water MELON. See ANGURIA, BOTANY *Index*.

MELOS, in *Ancient Geography*, an island between Crete and Peloponnesus, about 24 miles from Scyllæum. It is about 60 miles in circumference, and of an oblong figure. It enjoyed its independence for about 700 years before the time of the Peloponnesian war. This island was originally peopled by a Lacedæmonian colony, 1116 years before the Christian era. For this reason the inhabitants refused to join the rest of the islands and the Athenians against the Peloponnesians. This refusal was severely punished. The Athenians took Melos, and put to the sword all such as were able to bear arms. The women and children were made slaves, and the island left desolate. An Athenian colony

lony repeopled it, till Lysander reconquered it, and re-established the original inhabitants in their possessions.

MELOTHRIA, a genus of plants belonging to the triandria class; and in the natural method ranking under the 34th order, *Cucurbitaceæ*. See BOTANY *Index*.

MELPOMENE, in *Fabulous History*, one of the muses, daughter of Jupiter and Mnemosyne. She presided over tragedy. Horace has addressed the finest of his odes to her, as to the patroness of lyric poetry. She was generally represented as a young woman with a serious countenance. Her garments were splendid; she wore a buskin, and held a dagger in one hand, and in the other a sceptre and crown.

MELROSE, a town of Scotland, in the county of Selkirk, and on the confines of Tweedale, seated on the south side of the river Tweed; with an ancient abbey, now in ruins. W. Long. 2. 32. N. Lat. 55. 32.

This abbey was founded by King David I. in 1136. He peopled it with Cistertians brought from Rivale abbey in Yorkshire, and dedicated it to the Virgin Mary. At the Reformation James Douglas was appointed commendator, who took down much of the building, in order to furnish materials for a large house to himself, which still remains, and is dated 1590. Nothing is left of the abbey excepting a part of the cloister wall elegantly carved; but the ruins of the church are of most uncommon beauty. The sculpture is excellent, and the figures generally in good preservation. A few years ago the parish church was removed from the abbey, and a new church built at some distance from it. The rents of this abbey at the Reformation were, in money 1144l. 15s. 4d. wheat, 19 ch. 9 bolls, bear 77 ch. 3 bolls, meal 14 ch., oats 47 ch. 1 boll, butter 105 stone, salt 8 ch., capons 104, poultry 520, peats 340 load. These measures are one-third more than the standard. Alexander II. was buried beneath the great altar, and it is also the place of interment of the Douglases and other potent families.—Its situation is extremely pleasant.

MELT OF FISHES. In the melt of a living cod there are such numbers of those animalcules said to be found in the semen of all male animals, that in a drop of its juice no larger than a grain of sand, there are contained more than 10,000 of them; and considering how many such quantities there are in the whole melt of one such fish, it is not incredible, that there are more animals in one melt of it than there are living men at one time upon the face of the earth.

MELTING CONE, in essaying, an hollow cone of brass or cast iron, into which melted metalline substances are thrown, in order to free them from their scoriæ. When a small quantity of matter is melted, it will be sufficient to rub the inside of the cone with grease; but when the quantity is large, especially if it contains any thing sulphureous, this caution of tallowing the moulds is not sufficient. In this case the essayer has recourse to a lute reduced to thin pap with water, which effectually prevents any injury to the cone.

MELTON MOUBRAY, a town of Leicestershire, 108 miles from London. It is a large well-built place, in a fertile soil; with a market on Tuesday, the most considerable for cattle of any in this part of the island. It is almost encompassed with a little river called the *Eye*, over which it has two fine bridges; and has a large handsome church, with a free school. Here are frequent horse races, and three fairs in the year.

MELVIL, SIR JAMES, descended from an honourable Scots family, being the third son of the laird of Kaeth, was born about the middle of the 16th century. He went to France very young, in the capacity of page to Queen Mary, then married to the dauphin; and on the death of her husband, followed her to Scotland, where he was made gentleman of her chamber, and admitted a privy counsellor. She employed him in her most important concerns, till her unhappy confinement in Lochleven, all which he discharged with the utmost fidelity; and, from his own accounts, there is reason to conclude, that, had she taken his advice, she might have avoided many of her misfortunes. When she was prisoner in England, she recommended him strongly to her son James; with whom he continued in favour and employment until the death of Queen Elizabeth: James would then have taken him to England; but Melvil, now grown old, was desirous of retiring from business, and in his retirement he drew up the memoirs of his past life for the use of his son. These Memoirs were accidentally found in Edinburgh castle in the year 1660, though nobody knew how they came to be deposited there; and were published in folio in 1683.

MEMBERS, in *Anatomy*, the exterior parts, arising from the trunk or body of an animal like the boughs from the trunk of a tree.

MEMBER, in *Architecture*, denotes any part of a building; as a frieze, cornice, or the like.

MEMBER is sometimes also used for moulding.

MEMBER, in *Grammar*, is applied to the parts of a period or sentence.

MEMBER is also used to denote some particular order or rank in a state or government: thus we say, "member of a corporation, member of parliament, member of the council," &c.

MEMBRANE, MEMBRANA, in *Anatomy*, a similar part of an animal body; being a thin, white, flexible, expanded skin, formed of several sorts of fibres interwoven together, and serving to cover or wrap up certain parts of the body. See ANATOMY *passim*.

MEMEL, or MEMMEL; a town of Prussia, situated on the northern extremity of the Curische Haf, an inlet of the sea about 70 miles in length, which is here joined to the Baltic by a narrow strait.—It is an ill built town, with narrow dirty streets; but remarkable for its extensive commerce, being provided with the finest harbour in the Baltic. In 1784, 996 ships, amongst which were 500 English, arrived here. The imports chiefly are, salt, iron, and salted herrings; the exports, which greatly exceed the imports, are amber, corn, hemp, flax, and particularly timber. An English consul resides here. The trade increased greatly on account of the high duties laid on the imports of Riga. E. Long. 21. 25. N. Lat. 55. 50.

MEMNON, in fabulous history, a king of Ethiopia, son of Tithonus and Aurora. He came with a body of 10,000 men to assist his uncle Priam, during the Trojan war. He behaved with great courage, and killed Antilochus, Nestor's son. The aged father challenged

Memnon Memory.

lenged the Ethiopian monarch; but Memnon refused it on account of the venerable age of Nestor, and accepted that of Achilles. He was killed in the combat, in the sight of the Grecian and Trojan armies. Aurora prayed to Jupiter to grant her son such honours as might distinguish him from other mortals. The god consented; and immediately a numerous flight of birds issued from the burning pile on which the body was laid, and dividing themselves into two separate bodies, fought with such fury, that above half of them fell down in the fire as victims to appease the manes of Memnon. These birds were called *Memnonides;* and it has been observed by some of the ancients, that they never failed to return yearly to the tomb of Memnon in Troas, and repeat the same bloody engagement in honour of the hero from whom they received their name. The Ethiopians or Egyptians, over whom Memnon reigned, erected a celebrated statue to the honour of their monarch. This statue had the wonderful property of uttering a melodious sound every day at sunrising, like that which is heard at the breaking of the string of a harp when it is wound up. This was effected by the rays of the sun when they fell upon it. At the setting of the sun, and in the night, the sound was lugubrious. This is supported by the testimony of the geographer Strabo, who confesses himself ignorant whether it proceeded from the basis of the statue, or the people that were then around it. This celebrated statue was dismantled by order of Cambyses when he conquered Egypt; and its ruins still astonish modern travellers by their grandeur and beauty.

MEMNON of Rhodes, one of the generals of Darius king of Persia, advised that prince to lay waste the country, in order to deprive Alexander the Great's army of support, and afterwards to attack Macedon; but this counsel was disapproved by Darius's other generals. Memnon behaved at the passage of the Granicus like an experienced general. He afterwards defended the city of Miletum with great courage; seized the islands of Chios and Lesbos; spread terror throughout all Greece; and would have put a stop to the conquests of Alexander, if he had not been prevented by death. Barsina, Memnon's widow, was taken prisoner with Darius's wife, and Alexander had a son by her named *Hercules*.

MEMOIRS, in matters of literature, a species of history, written by persons who had some share in the transactions they relate; answering to what the Romans called *Commentarii.*—The journals of the proceedings of a literary society, or a collection of matters transacted therein, are likewise called *Memoirs*.

MEMORY, a faculty of the mind, which presents to us ideas or notions of what is past, accompanied with a persuasion that the things themselves were formerly real and present. What we distinctly remember to have perceived, we as firmly believe to have happened, as what is now present to our senses.

The opinions of philosophers concerning the means by which the mind retains the ideas of past objects, and how those ideas carry with them evidence of their objects having been actually perceived, shall be laid before our readers in another place: (see METAPHYSICS, Part I. chap. ii.). At present we shall throw together some observations on the memory, which, being of a practical rather than of a speculative nature, cannot be admitted into the article where the nature of the faculty itself is discussed.

"When we remember with little or no effort, it is called *remembrance* simply, or *memory*, and sometimes *passive memory* *. When we endeavour to remember what does not immediately (and as it were) of itself occur, it is called *active memory* or *recollection*. A ready recollection of our knowledge, at the moment when we have occasion for it, is a talent of the greatest importance. The man possessed of it seldom fails to distinguish himself in whatever sort of business he may be engaged." It is indeed evident, that when the power of retention is weak, all attempts at eminence of knowledge must be vain; for "memory is the primary and fundamental power †, without which there could be no other intellectual operation. Judgment and ratiocination suppose something already known, and draw their decisions only from experience. Imagination selects ideas from the treasures of remembrance, and produces novelty only by varied combinations. We do not even form conjectures of distant, or anticipations of future events, but by concluding what is possible from what is past."

* Beattie's Elements of Moral Science.

† Idler.

Of a faculty so important, many rules have been given for the regulation and improvement; of which the first is, that he who wishes to have a clear and distinct remembrance, should be temperate with respect to eating, drinking, and sleep. The memory depends very much upon the state of the brain; and therefore whatever is hurtful to the latter, must be prejudicial to the former. Too much sleep clouds the brain, and too little overheats it; therefore either of these extremes must of course hurt the memory, and ought carefully to be avoided. Intemperance of all kinds, and excess of passion, have the same ill effects; so that we rarely meet with an intemperate person whose memory is at once clear and tenacious.

"The liveliest remembrance is not so vivid as the sensation that produced it ‡; and ideas of memory do often, but not always, decay more and more, as the original sensation becomes more and more remote in time. Those sensations and those thoughts have a chance to be long remembered which are lively at first; and those are likely to be most lively which are most attended to, or which are accompanied with pleasure or pain, with wonder, surprise, curiosity, merriment, and other lively passions. The art of memory, therefore, is little more than the art of attention. What we wish to remember we should attend to, so as to understand it perfectly, fixing our view particularly upon its importance or singular nature, that it may raise within us some of the passions above mentioned. We should also disengage our minds from all other things, that we may attend more effectually to the object which we wish to remember. No man will read with much advantage who is not able at pleasure to evacuate his mind, or who brings not to his author an intelleet defecated and pure, neither turbid with care, nor agitated with pleasure. If the repositories of thought are already full, what can they receive? If the mind is employed on the past or the future, the book will be held before the eyes in vain.

‡ Beattie's Elements, &c. and Idler.

"It is the practice of many readers, to note in the margin of their books the most important passages §, the

§ Elements of Moral Science.

Memory.

the strongest arguments, or the brightest sentiments. Thus they load their minds with superfluous attention, repress the vehemence of curiosity by useless deliberation, and by frequent interruption break the current of narration or the chain of reason, and at last close the volume and forget the passages and the marks together. Others are firmly persuaded, that nothing is certainly remembered but what is transcribed; and they, therefore, pass weeks and months in transferring large quotations to a common-place-book. Yet, why any part of a book which can be consulted at pleasure should be copied, we are not able to discover. The hand has no closer correspondence with the memory than the eye. The act of writing itself distracts the thoughts; and what is read twice, is commonly better remembered than what is transcribed. This method, therefore, consumes time, without assisting the memory. But to write an abridgment of a good book may sometimes be a very profitable exercise. In general, when we would preserve the doctrines, sentiments, or facts, that occur in reading, it will be prudent to lay the book aside, and put them in writing in our own words. This practice will give accuracy to our knowledge, accustom us to recollection, improve us in the use of language, and enable us so thoroughly to comprehend the thoughts of other men, as to make them in some measure our own."

"Our thoughts have for the most part a connection *; so that the thought which is just now in the mind, depends partly upon that which went before, and partly serves to introduce that which follows.—Hence we remember best those things of which the parts are methodically disposed and mutually connected. A regular discourse makes a more lasting impression upon the hearer than a parcel of detached sentences, and gives to his rational powers a more salutary exercise: and this may show us the propriety of conducting our studies, and all our affairs, according to a regular plan or method. When this is not done, our thoughts and our business, especially if in any degree complex, soon run into confusion."

* *Idler.*

As the mind is not at all times equally disposed for the exercise of this faculty, such seasons should be made choice of as are most proper for it. The mind is seldom fit for attention presently after meals; and to call off the spirits at such times from their proper employment in digestion, is apt to cloud the brain, and prejudice the health. Both the mind and body should be easy and undisturbed when we engage in this exercise, and therefore retirement is most fit for it: and the evening, just before we go to rest, is generally recommended as a very convenient season, both from the stillness of the night, and because the impressions will then have a longer time to settle before they come to be disturbed by the accession of others proceeding from external objects; and to call over in the morning what has been committed to the memory overnight, must, for the same reason, be very serviceable. For, to review those ideas while they continue fresh upon the mind, and unmixed with any others, must necessarily imprint them more deeply.

Some ancient writers speak of an artificial memory, and lay down rules for attaining it. Simonides the poet is said first to have discovered this, or at least to have given the occasion for it. The story they tell of him is this: Being once at a feast, he recited a poem which he had made in honour of the person who gave the entertainment. But having (as is usual in poetry) made a large digression in praise of Castor and Pollux; when he had repeated the whole poem, his patron would give him but half the sum he had promised, telling him he must get the other part from those deities who had an equal share in the honour of his performance. Immediately after, Simonides was told that two young men were without, and must needs speak with him. He had scarcely got out of the house, when the room where the company was fell down, killed all the persons in it, and so mashed the bodies, that, when the rubbish was thrown off, they could not be known one from another: upon which Simonides recollecting the place where every one had sat, by that means distinguished them. Hence it came to be observed, that to fix a number of places in the mind in a certain order, was a help to the memory: As we find by experience, that, upon returning to places once familiar to us, we not only remember them, but likewise many things we both said and did in them. This action therefore of Simonides was afterwards improved into an art; and the nature of it is this: They bid you form in your mind the idea of some large place or building, which you may divide into a great number of distinct parts, ranged and disposed in a certain order. These you are frequently to revolve in your thoughts, till you are able to run them over one after another without hesitation, beginning at any part. Then you are to impress upon your mind as many images of living creatures, or any other insensible objects which are most likely to affect you, and be soonest revived in your memory. These, like characters in shorthand, or hieroglyphics, must stand to denote an equal number of other words, which cannot so easily be remembered. When therefore you have a number of things to commit to memory in a certain order, all that you have to do is, to place these images regularly in the several parts of your building. And thus they tell you, that, by going over several parts of the building, the images placed in them will be revived in the mind; which of course will give you the things or words themselves in the order you desire to remember them. The advantage of the images seems to be this; that, as they are more like to affect the imagination than the words for which they stand, they will for that reason be more easily remembered. Thus, for instance, if the image of a *lion* be made to signify *strength*, and this word *strength* be one of those I am to remember, and is placed in the porch; when, in going over the several parts of the building, I come to the porch, I shall sooner be reminded of that image than of the word *strength.* Of this artificial memory, both Cicero and Quintilian speak; but we know not of any modern orator that has ever made use of it. It seems indeed to have been a laborious way of improving the memory, if it serves that end at all, and fitter for assisting us to remember any number of unconnected words than a continual discourse, unless so far as the remembrance of one word may enable us to recollect more. It is, however, in allusion to it, that we still call the parts of a discourse

Memory, Mnemonica. places or topics, and say, *in the first place, in the second place*, &c.

But, doubtless, the most effectual way to gain a good memory, is by constant and moderate exercise of it; for the memory, like other habits, is strengthened and improved by daily use. It is indeed hardly credible, to what a degree both active and passive remembrance may be improved by long practice. *Scaliger* reports of himself, that in his youth he could repeat above 100 verses, having once read them; and *Berthecus* declares, that he wrote his *Comment upon Claudian* without consulting the text. To hope, however, for such degrees of memory as these, would be equally vain as to hope for the strength of *Hercules*, or the swiftness of *Achilles*. "But there are clergymen who can get a sermon by heart * in two hours, though their memory, when they began to exercise it, was rather weak than strong: And pleaders, with other orators who speak in public and *extempore*, often discover, in calling instantly to mind all the knowledge necessary on the present occasion, and every thing of importance that may have been advanced in the course of a long debate, such powers of retention and recollection as, to the man who has never been obliged to exert himself in the same manner, are altogether astonishing. As habits, in order to be strong, must be formed in early life, the memories of children should, therefore, be constantly exercised; but to oblige them to commit to memory what they do not understand, perverts their faculties, and gives them a dislike to learning." In a word, those who have most occasion for memory, as orators and public speakers, should not suffer it to lie idle, but constantly employ it in treasuring up and frequently reviving such things as may be of most importance to them; for by these means it will be more at their command, and they may place greater confidence in it upon any emergency."

* *Id.*

"Men complain of nothing more frequently than of deficient memory †: and indeed every one finds, that after all his efforts, many of the ideas which he desired to retain have slipped irretrievably away; that acquisitions of the mind are sometimes equally fugitive with the gifts of fortune; and that a short intermission of attention more certainly lessens knowledge than impairs an estate. To assist this weakness of our nature, many methods besides those which we have mentioned have been proposed; all of which may be justly suspected of being ineffectual: for no art of memory, however its effects may have been boasted or admired, has been ever adopted into general use; nor have those who possessed it appeared to excel others in readiness of recollection or multiplicity of attainments." The reader who is desirous to try the effect of those helps, may have recourse to a treatise entitled *A new Method of Artificial Memory*; but the true method of memory is attention and exercise.

† *Elements of Moral Science.*

MNEMONICA, or the art of memory, as it was called by the ancients, has been lately revived and studied in Germany and France. In some notices concerning this subject which we have seen, it is observed that this science is more intimately connected with the Egyptian hieroglyphics than is generally thought, and that this connection may help to explain them. In Germany this art has been revived by M. Aretin; and a pupil of his, M. Kaestner, has been permitted to teach the new doctrine at Leipsic, but on the express condition of not allowing his hearers to write down his lectures. This seems to be a singular, and we may add a silly prohibition. The following account is given of this art in a letter from Paris in the beginning of 1807. "During my residence, says the writer, in this metropolis I heard a great deal of a new method of *mnemonique*, or of a method to assist and fix our memory, invented by Gregor de Feinaigle. Notwithstanding the simplicity with which he announced his lectures in the papers, I could not determine myself to become a pupil of his, as I thought to find a quack or mountebank, and to be laughed at by my friends for having thrown away my cash in such a foolish manner. Perhaps I should hesitate to this moment about the utility of this newly invented method to assist our natural memory, had I not had the pleasure of dining at his excellency's the count of Metternich, the Austrian ambassador, who followed, with all his secretaries, the whole course of lectures; they all spoke very advantageously of it, likewise several other persons of the first rank I met there: in consequence of this I was inserted into the list of pupils, and I follow at this moment the lectures. All I can tell you about this method is, it is a very simple one, and easy to be learned, adapted to all ages and sexes: all difficulties in such sciences as require an extraordinary good memory, for instance, the names and epochs in history, are at once overcome and obviated. There is not one branch of science to which this method cannot be applied. It is easy to be perceived that such an invention cannot pass without some critique, and even sarcasms, in the public prints: some of them were very injurious, and plausible enough to mislead the public, who, knowing nothing of the method, are always more ready to condemn than to assist. M. Feinaigle, to answer all these critics at once, adopted a method not less public for Paris than the public papers, but less public for the rest of Europe: he gave, the 22d of last month, a public exhibition to about 2000 spectators, in which he did not appear at all, only about 12 or 15 of his pupils: each of them made such an application of the method as his situation in life required. The principal parts were the following: history, about names and years; geography, with respect to longitude, latitude, number of inhabitants, square miles, &c. &c.; grammar in various languages, about different editions of the same work; pandects, their division, and title of each book, title, &c.; different systems of botany, poetry, arithmetic, &c. &c. At last one desired the company to give him one thousand words, without any connection whatsoever, and without numeric order; for instance, the word *astronomer*, for N° 62; *wood*, for N° 188; *lovely*, for N° 370; *dynasty*, for N° 23; *David*, for N° 90, &c. &c. till all the numbers were filled; and he repeated the whole (notwithstanding he heard these words without order, and but once), in the numerical order; or he told you what word was given against any one number, or what number any one word bore. It is still more striking, but certainly likewise more difficult, to retain as many numbers however great they may be. For words and numbers I could venture myself, with the greatest safety, as far as one hundred of each; and I am sure, after having

Mnemonica, Memphis.

having fixed them once, which is done in less than ten minutes, I could repeat them to you at any period, without ever thinking any more of them*."

Feinaigle afterwards delivered lectures on the same subject to crowded audiences in London, Edinburgh, Glasgow, &c.; but we do not find that any of his pupils received improvement from his instructions, and very few of them could give any account of his method.

* *Phil. Mag.* 28. 93.

MEMPHIS, an ancient city, and the royal residence of the kings in the Higher Egypt; distant from the Delta to the south 15 miles, according to Pliny. Called also *Moph*, and *Noph*, in scripture.

Though this city is now so completely ruined, that authors greatly disagree concerning its situation; yet Strabo informs us that in his time it was the most magnificent in Egypt, next to Alexandria, and called the capital of the country; and there was an entire temple of Osiris, where the Apis or sacred ox was kept and worshipped. In the same place was an apartment of the mother of the ox; a very magnificent temple of Vulcan; a large circus or space for fighting bulls; and a great colossus in the middle of the city, which was thrown down. There was likewise a temple of Venus, and a Serapium in a very sandy place, where the wind heaps up hills of sand very dangerous to travellers; together with a number of sphinxes, the heads of some of them only being visible. In the front of the city there were many lakes; and it contained a number of palaces, at that time in ruins. These buildings formerly stood upon an eminence: they lay along the side of the hill, stretching down to the lakes and groves, 40 stadia from the city. On a mountain in the neighbourhood, there was a great number of pyramids, with the sepulchres of the kings. From this description, Mr Bruce concludes that the celebrated capital of Egypt stood in the place where the villages of Metrahenny are now situated; in opposition to Dr Shaw's opinion, who thinks it was situated at Geeza or Gisa.

M. Savary has also shown, that Gisa was not the situation of the ancient Memphis, which stood, he says, on the spot where the village of Memph now stands. Large heaps of rubbish are still to be seen there; but the Arabs have transported to Cairo the columns and remarkable stones, which they have disposed, without taste and without order, in their mosques and public buildings. This city extended as far as Saccara; and was almost wholly encompassed by lakes, part of which are still subsisting. It was necessary to cross them to convey the dead to the sepulchres of their fathers. The tombs, hewn out of the rock, were closed up with stones of a proportionable size, and covered with sand. These bodies embalmed with so much care, preserved with so much respect, are torn from the monuments they repose in, and sold without decency to strangers by the inhabitants of Saccara. This place is called *the plain of mummies*. There too we find *the well of the birds*, into which one descends by means of a rope. It leads to subterraneous galleries, filled with earthen vases containing the sacred birds. They are rarely met with entire, because the Arabs break them in hopes of finding idols of gold. They do not conduct travellers into the places where they have found more precious articles. They even close them up carefully, reserving to themselves some secret passages by which they descend. In a journey into Egypt made by the duke de Chaulnes, he advanced very far into these winding labyrinths, sometimes crawling, and sometimes scrambling on his knees. Informed by Mr Edward Wortley Montague, who has carefully visited Egypt, he arrived at one of those passages which had an opening shut up from without by branches of the date tree interwoven, and covered with sand. He remarked there some hieroglyphics *in relievo*, executed in the highest perfection. But the Arabs resisted every offer he made them to permit him to take drawings of them, or to mould them, in order to preserve their form. The duke de Chaulnes is of opinion that these hieroglyphics, sculptured with so much art that the objects they represent may be discovered at the first sight, might possibly furnish the key of the others, whose contours are simply expressed, and form a sort of alphabet of this unintelligible language. Several pyramids are distinguishable along the mountains which bound Saccara on the west, the greatest part of which appear as lofty as those of Gisa. See PYRAMIDS.

Memphis || Menander.

MENAGE (Fr.), denotes a collection of animals; whence we have derived the word *menagery*.

MENANDER, an ancient Greek poet, was born at Athens in the same year with Epicurus, which was the third of the 109th Olympiad. His happiness in introducing the new comedy, and refining an art which had been so gross and licentious in former times, quickly spread his name over the world. Pliny informs us, that the kings of Egypt and Macedon gave a noble testimony of his merit, by sending ambassadors to invite him to their courts, and even fleets to bring him over; but that Menander was so much of a philosopher, as to prefer the free enjoyment of his studies to the promised favours of the great. Of his works, which amounted to above 100 comedies, we have had a double loss, the originals being not only vanished, but the greatest part of them, when copied by Terence, having unfortunately perished by shipwreck before they saw Rome. Yet the four plays which Terence borrowed from him before that accident happened, are still preserved in the Roman habit; and it is chiefly from Terence that most people form their judgment of Menander, the fragments that remain of him not being sufficient to enable them to do it. The ancients have said high things of Menander; and we find the old masters of rhetoric recommending his works as the true patterns of every beauty and every grace of public speaking. Quintilian declares, that a careful imitation of Menander only, will satisfy all the rules he has laid down in his Institutions. It is in Menander that he would have his orator search for a copiousness of invention, for a happy elegance of expression, and especially for that universal genius which is able to accommodate itself to persons, things, and affections.—But Julius Cæsar has left the loftiest as well as the justest praise of Menander's works, when he calls Terence only a *Half-Menander*. For while the virtues of the Latin poet are so deservedly admired, it is impossible we should raise a higher notion of excellency than to conceive the great original still shining with half its lustre unreflected, and preserving an equal part of its graces, above the power of the best copier in the world. Menander died in the 3d year of the 122d Olympiad,

Olympiad, as we are taught by the same old inscription from which we learn the time of his birth. His tomb, in Pausanias's age, was to be seen at Athens, in the way from the Piræus to the city, close by the honorary monument of Euripides. Quintilian, in his judgement of Afranius the Roman comedian, who imitated him, censures Menander's morals as much as he commends his writings; and his character, according to Suidas, is, that he was a very "mad fellow after women." Phædrus has given him the gait and dress of a most affected fop:

"Unguento delibutus, vestitu adfluens,
"Veniebat gressu delicatulo et languido."
Lib. v. fab. 2.

MENANDRIANS, the most ancient branch of Gnostics; thus called from Menander their chief, said by some, without sufficient foundation, to have been a disciple of Simon Magus, and himself a reputed magician.

He taught, that no person could be saved, unless he were baptized in his name; and he conferred a peculiar sort of baptism, which would render those who received it immortal in the next world: exhibiting himself to the world, with the phrensy of a lunatic more than the founder of a sect, as a promised saviour. For it appears by the testimonies of Irenæus, Justin, and Tertullian, that he pretended to be one of the æons sent from the pleroma, or ecclesiastical regions, to succour the souls that lay groaning under bodily oppression and servitude; and to maintain them against the violence and stratagems of the dæmons that hold the reins of empire in this sublunary world. As this doctrine was built upon the same foundation with that of Simon Magus, the ancient writers looked upon him as the instructor of *Menander*. See SIMONIANS.

MENASSEH BEN ISRAEL, a celebrated rabbi, born in Portugal about the year 1604, was the son of Joseph Ben Israel, and followed his father into Holland. Here he was educated by Rabbi Isaac Uziel, under whom he in a short time made such progress in the Hebrew tongue, that at 18 years of age he succeeded him in the synagogue of Amsterdam. In this post he continued several years, and married Rachel of the family of the Abarbanels, whom the Jews imagine to be descended from King David. He afterwards went to his brother Ephraim, a rich merchant, who had settled at Basil; by whose advice he entered into trade. Some time after, the hopes of a more agreeable settlement induced him to come into England, under the protectorship of Cromwell; who gave him a very favourable reception, and one day entertained him at his table with several other learned divines. However, he soon after passed into Zealand; and died at Middleburg about the year 1657. The Jews at Amsterdam obtained his body, and interred it at their expence. He was of the sect of the Pharisees; had a lively wit, a solid judgment, great learning, and all the virtues that can adorn private life. He wrote many works in Hebrew, Latin, Spanish, and English. The principal of those published in Latin, are, 1. His *Conciliator*; a learned and curious work, in which he reconciles those passages of Scripture which seem to contradict each other. 2. *De resurrectione mortuorum.* 3. *De termino vitæ.* 4. *Dissertatio de fragilitate humana, ex lapsu Adami, deque Divino in bono opere auxilio.* 5. *Spes Israel.* Dr Thomas Pococke has written his life in English.

MENDELSHON, MOSES, that is, *Moses the son of Mendel*, a Jew of Berlin, and one of the most celebrated writers of Germany, died there in the year 1785 at the age of 57. His first attempt as an author was soon after 1767, by a work entitled *Jerusalem*; in which, besides other bold and unjustifiable opinions; he maintains, that the Jews have a revealed law but not a revealed religion; that opinions are not subjects of revelation; and that the only religion of the Jewish nation is that of nature. He acquired great honour by his *Phædon*, or "Discourses on the Immateriality and Immortality of the Soul," translated into the French 1773, 8vo; in which he unfolds this important truth, the great foundation of all morality, with the wisdom of an enlightened philosopher and the charms of an elegant writer. In consequence of this excellent work, he was styled the *Jewish Socrates* by some of the periodical writers; but he wanted the firmness and courage of the Grecian philosopher. His timidity, and even pusillanimity, defects too common to speculative men, prevented him from being of any essential service to his nation; of which he might have become the benefactor by being the reformer. The pliancy of his character, his soft, modest, and obliging disposition, gained him the esteem alike of the superstitious and of the incredulous. After all, he could never procure admission to the Berlin society, or to the conversation of the king of Prussia. At his death he received from his nation those honours which are commonly paid to their first rabbins. Contrary to an imprudent custom prevalent among the Jews of burying their dead before sunset, his interment was delayed till 24 hours after he expired. Though Mendelshon was descended from a respectable family, he was very poor. In early life he entered into a counting-house of his own nation, wherein he greatly recommended himself by his capacity and integrity in business: But philosophy and literature soon became his principal occupation; and to the famous Lessing he was indebted for counsels which, without diverting his attention from those pursuits that were necessary to his subsistence, accelerated his progress in his literary career. Even after the death of his benefactor, Mendelshon retained for him the sincerest regard and the most lively gratitude. Notwithstanding the very strict regimen which he observed, he survived him only a few years; for his feeble frame and weak constitution were gradually and insensibly undermined by intense application to study.

MENDEZ PINTO, FERDINAND, was born at Montemor-o-velho in Portugal, and was at first servant to a Portuguese gentleman. In expectation of making a fortune, he embarked for India in 1537. His vessel being taken by the Turks on his passage, he was carried to Mocka, and sold to a Greek renegado, and afterwards to a Jew, in whose possession he continued till he was redeemed by the governor of Ormus, a Portuguese fort. The governor procured him an opportunity of going out to India, agreeable to his first design. During a residence of twenty-one years in that country, he was witness to very important transactions, and experienced many singular adventures. He returned to Portugal in 1558, where he enjoyed the reward

Mendez, Mendicants.

ward of his labours, after having been thirteen times a slave and sixteen times sold. A very curious account of his travels was written by himself, and published at Lisbon, A. D. 1614, in folio. This work was translated into French by Bernard Figuier, a Portuguese gentleman, and printed at Paris 1654, in 4to. It is written in a very interesting manner, and in a style more elegant than might have been expected from a man whose whole life was spent in the camp and in slavery. It elucidates a great variety of particulars relating to the geography, history, and manners of the inhabitants of China, Japan, Pegu, Siam, Achem, Java, &c. Many of his facts appeared fabulous, but their truth has been since ascertained. M. de Surgi compiled an interesting history from the most singular facts in Mendez Pinto's relation, which he published in the *Vicissitudes de la Fortune*, Paris, 2 vols. 8vo.

MENDICANTS, or Begging Friars, several orders of religious in Popish countries, who having no settled revenues, are supported by the charitable contributions they receive from others.

This sort of society began in the 13th century; and the members of it, by the tenor of their institution, were to remain entirely destitute of all fixed revenues and possessions; though in process of time their number became a heavy tax upon the people. Innocent III. was the first of the popes who perceived the necessity of instituting such an order; and accordingly he gave such monastic societies, as made a profession of poverty, the most distinguishing marks of his protection and favour. They were also encouraged and patronized by the succeeding pontiffs, when experience had demonstrated their public and extensive usefulness. But when it became generally known, that they had such a peculiar place in the esteem and protection of the rulers of the church, their number grew to such an enormous and unwieldy multitude, and swarmed so prodigiously in all the European provinces, that they became a burden, not only to the people, but to the church itself. The great inconvenience that arose from the excessive multiplication of the mendicant orders was remedied by Gregory X. in a general council, which he assembled at Lyons in 1272. For here all the religious orders that had sprung up after the council held at Rome in 1215, under the pontificate of Innocent III. were suppressed; and the extravagant multitude of mendicants, as Gregory called them, were reduced to a smaller number, and confined to the four following societies or denominations, viz. the Dominicans, the Franciscans, the Carmelites, and the Augustins or hermits of St Augustin.

As the pontiffs allowed these four mendicant orders the liberty of travelling wherever they thought proper, of conversing with persons of every rank, of instructing the youth and multitude wherever they went; and as those monks exhibited, in their outward appearance and manner of life, more striking marks of gravity and holiness than were observable in the other monastic societies, they arose all at once to the very summit of fame, and were regarded with the utmost esteem and veneration through all the countries of Europe. The enthusiastic attachment to these sanctimonious beggars went so far, that, as we learn from the most authentic records, several cities were divided or cantoned out into four parts, with a view to these four orders; the first part being assigned to the Dominicans, the second to the Franciscans, the third to the Carmelites, and the fourth to the Augustins. The people were unwilling to receive the sacraments from any other hands than those of the mendicants, to whose churches they crowded to perform their devotions, while living, and were extremely desirous to deposit there also their remains after death: nor did the influence and credit of the mendicants end here; for we find in the history of this and of the succeeding ages, that they were employed not only in spiritual matters, but also in temporal and political affairs of the greatest consequence, in composing the differences of princes, concluding treaties of peace, concerting alliances, presiding in cabinet councils, governing courts, levying taxes, and other occupations, not only remote from, but absolutely inconsistent with, the monastic character and profession. However, the power of the Dominicans and Franciscans greatly surpassed that of the other two orders: insomuch that these two orders were, before the Reformation, what the Jesuits have been since that happy and glorious period, the very soul of the hierarchy, the engines of the state, the secret springs of all the motions of the one and the other, and the authors and directors of every great and important event, both in the religious and political world. By very quick progression their pride and confidence arrived at such a pitch, that they had the presumption to declare publicly, that they had a divine impulse and commission to illustrate and maintain the religion of Jesus; they treated with the utmost insolence and contempt all the different orders of the priesthood; they affirmed, without a blush, that the true method of obtaining salvation was revealed to them alone; proclaimed, with ostentation, the superior efficacy and virtue of their indulgencies; and vaunted beyond measure their interest at the court of heaven, and their familiar connexions with the Supreme Being, the Virgin Mary, and the saints in glory. By these impious wiles, they so deluded and captivated the miserable, and blinded the multitude, that they would not entrust any other but the mendicants with the care of their souls. They retained their credit and influence to such a degree, towards the close of the 14th century, that great numbers of both sexes, some in health, others in a state of infirmity, and others at the point of death, earnestly desired to be admitted into the mendicant order, which they looked upon as a sure and infallible method of rendering heaven propitious. Many made it an essential part of their last wills, that their bodies after death should be wrapped in old ragged Dominican or Franciscan habits, and interred among the mendicants. For such was the barbarous superstition and wretched ignorance of this age, that people universally believed they should readily obtain mercy from Christ, at the day of judgment, if they appeared before his tribunal associated with the mendicant friars.

About this time, however, they fell under an universal odium; but being resolutely protected against all opposition, whether open or secret, by the popes, who regarded them as their best friends and most effectual supports, they suffered little or nothing from the efforts of their numerous adversaries. In the 15th century,

century, besides their arrogance, which was excessive, a quarrelsome and litigious spirit prevailed among them, and drew upon them justly the displeasure and indignation of many. By affording refuge at this time to the Beguins in their order, they became offensive to the bishops, and were hereby involved in difficulties and perplexities of various kinds. They lost their credit in the 16th century by their rustic impudence, their ridiculous superstitions, their ignorance, cruelty, and brutish manners. They discovered the most barbarous aversion to the arts and sciences, and expressed a like abhorrence of certain eminent and learned men, who endeavoured to open the paths of science to the pursuits of the studious youth, recommended the culture of the mind, and attacked the barbarism of the age in their writings and discourse. Their general character, together with other circumstances, concurred to render a reformation desirable, and to accomplish this happy event.

Among the number of mendicants are also ranked the Capuchins, Recollects, Minims, and others, who are branches or derivations from the former.

Buchanan tells us, the mendicants in Scotland, under an appearance of beggary, lived a very luxurious life; whence one wittily called them, not *Mendicant* but *Manducant* friars.

MENE, a Chaldean word, which signifies "he has numbered or counted;" being one of the three words that were written upon the wall by the hand that appeared to Belshazzar, the last king of Babylon, the night that he was put to death. See BELSHAZZAR.

MENECRATES, a physician of Syracuse, who flourished about 360 B. C. is famous for his skill in his profession, but much more for his vanity. He would always be followed by some of the patients he had cured, and with whom he previously stipulated that they should follow him wherever he went. One appeared with the attributes of Hercules, another with those of Apollo, and others again with those of Mercury or Æsculapius; while he, clad in a purple robe, with a golden crown on his head, and a sceptre in his hand, presented himself, to the admiration of the public, under the name of *Jupiter*, and travelled through different countries escorted by these counterfeit deities. He once wrote the following letter to the king of Macedon: Menecrates Jupiter to Philip, greeting. Thou reignest in Macedonia, and I in medicine; thou givest death to those who are in good health, I restore life to the sick; thy guard is composed of Macedonians; the gods themselves constitute mine." Philip answered him in a word, that he wished him restored to reason. Learning some time after that he was in Macedon, Philip sent for him, and invited him to an entertainment. Menecrates and his companions were placed on rich and lofty couches; before which was an altar, covered with the first fruits of the harvest; and, whilst an excellent repast was served up to the other guests, perfumes and libations only were offered to these new gods, who, unable to endure the affront, hastily left the palace, in which they never more made their appearance.

MENEDEMUS, a Greek philosopher, born at Erythreum, was the son of Calisthenes, and one of Phedo's followers. He was in the greatest esteem, and enjoyed several important posts, in his own country. He several times defended Erythreum with great bravery, and died of grief when Antigonus became master of it. A person one day saying to him, "It is a great happiness to have what we desire," he replied "It is a much greater to desire nothing but what we have." He flourished about 300 B. C.

MENELAUS, the son of Atreus, and the brother of Agamemnon, reigned at Sparta, when Paris deprived him of his wife Helen. This rape occasioned the famous war of Troy. See HELEN.

MENELAUS, a mathematician in the reign of the emperor Trajan, wrote three books on the *Sphere*, which have been published by Father Marsenne.

MENES, born at This, a town of Thebais in Upper Egypt, was the founder of the Egyptian empire. He had three sons, viz. Athotis, who ruled after him, at This and Thebes; Curudes, who in Lower Egypt founded the kingdom of Heliopoli, which afterward was the kingdom of Diospoli; and Necherophes, who reigned at Memphis. It is thought this Menes reigned 117 years after the birth of Phaleg, son of Heber, which was the very year of the dispersion of the people throughout the whole earth. In building Memphis, he stopped the Nile near it, by the invention of a causeway 100 furlongs broad, and caused it to run through the mountains.

MENIALS, domestic or household servants, who live under their lord or master's roof.

MENINGES, or MENYNGES, in *Anatomy*, a name given to the dura and pia mater of the brain. See ANATOMY, N° 129.

MENINX, an island in the Mediterranean, to the west of the Syrtis Minor. Supposed by Strabo and Polybius to be Homer's country of the Lotophagi; and hence Ptolemy and Eratosthenes denominate the island *Lotophagitis*, with a cognominal town *Meninx*. It was the country of Vibius Gallus the emperor, and of Volusianus. Now called *Gerbi* and *Zarbi*.

MENIPPUS, a cynic philosopher of Phœnicia. He was originally a slave, but obtained his liberty with a sum of money, and became one of the greatest usurers at Thebes. He grew so desperate from the continual reproaches and insults to which he was daily exposed on account of his meanness, that he destroyed himself. He wrote 13 books of satires, which have been lost.

MENIPPEAN (*satira MENIPPEA*), a kind of satire consisting of prose and verse intermixed. It is thus called from Menippus a cynic philosopher who delighted in composing satirical letters, &c. In imitation of him, Varro also wrote satires under the title of *Satiræ Menippeæ*: whence this sort of composition is also denominated *Varronian satire*.

Among the moderns there is a famous piece under this title first published in 1594, against the chiefs of the league, called also the *Catholicon* of Spain. It is esteemed a masterpiece for the time.

MENISCUS, in *Optics*, a glass or lens, concave on one side and convex on the other; sometimes also called *lunula*. See OPTICS.

MENISPERMUM, MOONSEED, a genus of plants belonging to the diœcia class, and in the natural method ranking under the 11th order, *Sarmentaceæ*. See BOTANY *Index*.

MENNITH, or MINNITH, Judges xi. 33. a town near

Mennith, Menno-nites. near Heshbon (Jerome), in Arabia Petræa; in a district named *Ecosipolis* or *twenty-towns*, (Cellarius). There is also a Minnith mentioned Ezekiel xxvii. as being in a good wheat country: but whether the same with the foregoing is uncertain; though some think that the first Minnith lay in the country of Ammon, (Wells).

MENNONITES, a sect in the United Provinces, in most respects the same with those in other places called *Anabaptists*.

They had their rise in 1536, when Menno Simon, a native of Friesland, who had been a Romish priest, and a notorious profligate, resigned his rank and office in the Romish church, and publicly embraced the communion of the Anabaptists.

Menno was born at Witmarsum, a village in the neighbourhood of Bolswert in Friesland, in the year 1505, and died in 1561 in the duchy of Holstein, at the country seat of a certain nobleman not far from the city of Oldesloe, who, moved with compassion by a view of the perils to which Menno was exposed, and the snares that were daily laid for his ruin, took him with certain of his associates into his protection, and gave him an asylum. The writings of Menno, which are almost all composed in the Dutch language, were published in folio at Amsterdam in the year 1651. About the year 1637, Menno was earnestly solicited by many of the sect with which he connected himself, to assume among them the rank and functions of a public teacher; and as he looked upon the persons who made this proposal to be exempt from the fanatical phrensy of their brethren at Munster, (though according to other accounts they were originally of the same stamp, only rendered somewhat wiser by their sufferings), he yielded to their entreaties. From this period to the end of his life, he travelled from one country to another with his wife and children, exercising his ministry, under pressures and calamities of various kinds, that succeeded each other without interruption, and constantly exposed to the danger of falling a victim to the severity of the laws. East and West Friesland, together with the province of Groningen, were first visited by this zealous apostle of the Anabaptists; from whence he directed his course into Holland, Guelderland, Brabant, and Westphalia, continued it through the German provinces that lie on the coasts of the Baltic sea, and penetrated as far as Livonia. In all these places his ministerial labours were attended with remarkable success, and added to his sect a prodigious number of followers. Hence he is deservedly considered as the common chief of almost all the *Anabaptists*, and the parent of the sect that still subsists under that denomination. Menno was a man of genius, undirected by a very sound judgment: he possessed a natural and persuasive eloquence, and such a degree of learning as made him pass for an oracle in the estimation of the multitude. He appears, moreover, to have been a man of probity, of a meek and tractable spirit, gentle in his manners, pliable and obsequious in his commerce with persons of all ranks and characters, and extremely zealous in promoting practical religion and virtue, which he recommended by his example as well as by his precepts. The plan of doctrine and discipline drawn up by Menno was of a much more mild and moderate nature than that of the furious and fanatical ANABAPTISTS, whose tumultuous proceedings have been recited under that article, but somewhat more severe, though more clear and consistent than the doctrine of the wiser branches of that sect, who aimed at nothing more than the restoration of the Christian church to its primitive purity. Accordingly he condemned the plan of ecclesiastical discipline that was founded on the prospect of a new kingdom, to be miraculously established by Jesus Christ on the ruins of civil government and the destruction of human rulers, and which had been the fatal and pestilential source of such dreadful commotions, such execrable rebellions, and such enormous crimes. He declared publicly his dislike of that doctrine, which pointed out the approach of a marvellous reformation in the church by the means of a new and extraordinary effusion of the Holy Spirit. He expressed his abhorrence of the licentious tenets, which several of the Anabaptists had maintained, with respect to the lawfulness of polygamy and divorce; and finally, considered as unworthy of toleration those fanatics who were of opinion that the Holy Ghost continued to descend into the minds of many chosen believers, in as extraordinary a manner as he did at the first establishment of the Christian church, and that he testified this peculiar presence to several of the faithful by miracles, predictions, dreams and visions of various kinds. He retained indeed the doctrines commonly received among the Anabaptists, in relation to the baptism of infants, the *millennium*, or 1000 years reign of Christ upon earth, the exclusion of magistrates from the Christian church, the abolition of war, and the prohibition of oaths enjoined by our Saviour, and the vanity as well as the pernicious effects of human science. But while Menno retained these doctrines in a general sense, he explained and modified them in such a manner as made them resemble the religious tenets that were universally received in the Protestant churches; and this rendered them agreeable to many, and made them appear inoffensive even to numbers who had no inclination to embrace them. It however so happened, that the nature of the doctrines considered in themselves, the eloquence of Menno which set them off to such advantage, and the circumstances of the times, gave a high degree of credit to the religious system of this famous teacher among the Anabaptists, so that it made a rapid progress in that sect. And thus it was in consequence of the ministry of Menno, that the different sorts of Anabaptists agreed together in excluding from their communion the fanatics that dishonoured it, and in renouncing all tenets that were detrimental to the authority of civil government, and by an unexpected coalition formed themselves into one community.

Though the Mennonites usually pass for a sect of Anabaptists, yet M. Herman Schyn, a Mennonite minister, who has published their history and apology, maintains, that they are not Anabaptists either in principle or by origin. However, nothing can be more certain than this fact, viz. that the first Mennonite congregations were composed of the different sorts of Anabaptists, of those who had been always inoffensive and upright, and of those who, before their conversion by the ministry of Menno, had been seditious fanatics: besides, it is alleged that the Mennonites

nites do actually retain, at this day, some of those opinions and doctrines, which led the seditious and turbulent Anabaptists of old to the commission of so many and such enormous crimes: such particularly is the doctrine concerning the nature of Christ's kingdom, or of the church of the New Testament, though modified in such a manner as to have lost its noxious qualities, and to be no longer pernicious in its influence.

The Mennonites are subdivided into several sects; whereof the two principal are the *Flandrians* or Flemingians, and the Waterlandians. The opinions, says Mosheim, that are held in common by the Mennonites, seem to be all derived from this fundamental principle, that the kingdom which Christ established upon earth is a visible church or community, into which the holy and just alone are to be admitted, and which is consequently exempt from all those constitutions and rules of discipline that have been invented by human wisdom, for the correction and reformation of the wicked. This principle, indeed, was avowed by the ancient Mennonites, but it is now almost wholly renounced: nevertheless, from this ancient doctrine, many of the religious opinions that distinguish the Mennonites from all other Christian communities, seem to be derived: in consequence of this doctrine, they admit none to the sacrament of baptism but persons that are come to the full use of their reason; they neither admit civil rulers into their communion, nor allow any of their members to perform the functions of magistracy; they deny the lawfulness of repelling force by force, and consider war, in all its shapes, as unchristian and unjust; they entertain the utmost aversion to the execution of justice, and more especially to capital punishments; and they also refuse to confirm their testimony by an oath. The particular sentiments that divided the more considerable societies of the Mennonites are the following: The rigid Mennonites, called the *Flemingians*, maintain with various degrees of rigour, the opinions of their founder Menno, as to the human nature of Christ, alleging that it was produced in the womb of the Virgin by the creating power of the Holy Ghost; the obligation that binds us to wash the feet of strangers, in consequence of our Saviour's command; the necessity of excommunicating and avoiding, as one would do the plague, not only avowed sinners, but also all those who depart, even in some light instances pertaining to dress, &c. from the simplicity of their ancestors; the contempt due to human learning, and other matters of less moment. However this austere system declines, and the rigid Mennonites are gradually approaching towards the opinions and discipline of the more moderate or *Waterlandians*.

The first settlement of the Mennonites, in the United Provinces, was granted them by William prince of Orange, towards the close of the 16th century; but it was not before the following century that their liberty and tranquillity were fixed upon solid foundations, when, by a confession of faith published in the year 1626, they cleared themselves from the imputations of those pernicious and detestable errors that had been laid to their charge. In order to appease their intestine discords, a considerable part of the Anabaptists of Flanders, Germany, and Friesland, concluded their debates in a conference held at Amsterdam, in the year 1630, and entered into the bonds of fraternal communion, each reserving to themselves a liberty of retaining certain opinions. This association was renewed and confirmed by new resolutions, in the year 1649; in consequence of which, the rigorous laws of Menno and his successors were, in various respects, mitigated and corrected.

MENOLOGY, Menologium, (from μην, *month*, and λογος, *discourse*), is much the same as martyrology, or calendar, in the Latin.

The Greek menologium is divided into the several months in the year; and contains an abridgment of the lives of the saints, with a bare enumeration of the names of such whose lives were never written. The Greeks have various menologies; and the Romans tax them with inserting divers heretics in their menologies as saints.—Baillet treats of them at large.

MENSA, in law books, a term that includes in it all patrimony, and necessaries for livelihood.

MENSALS, Mensalia, in church history, such livings as were formerly united to the tables of religious houses, and hence called *mensal benefices*. See the article Benefice.

MENSES, Catamenia, in *Medicine*, the monthly evacuations from the uterus of women not with child or not giving suck. They are so called from *mensis* "month," the period wherein they return. They are also called *flowers*, *courses*, &c. By the Jewish law a woman was unclean while the menstrual blood flowed; and the man who touched her, and the moveables she had touched, were declared unclean.—Lev. xv. See Midwifery and Medicine.

MENSORES, among the Romans, were harbingers, whose business it was to go before the emperor, and fix upon lodgings for him when he travelled into any of the provinces. They also marked out encampments, and assigned every regiment its post.

Mensores were also land-surveyors, architects, or appraisers of houses and public buildings. The distributors of provisions in the army were called *mensores frumentarii*. And mensores was also an appellation given to servants who waited at table.

MENSURATION.

Every branch of the mathematics which has for its object the comparison of geometrical quantities, and the determination of their proportions to each other, may be comprehended under the general name *Mensuration*. So that, taking the term in its most extensive sense, whatever is delivered in this work under the titles Geometry, Trigonometry, Conic Sections, part of Algebra, and a very considerable portion of Fluxions, may be considered as constituting particular branches of this general theory.

The

Tables of Measures.

The term mensuration, however, is also frequently used in a less extensive sense, and is applied to a system of rules and methods by which numerical measures of geometrical quantities are obtained. And it is to this limited view of the subject that we propose to confine our attention in the present treatise. In general, it will only be necessary to give the practical rules, as we have already explained their foundation when treating of GEOMETRY, CONIC SECTIONS, and FLUXIONS; but, in addition to the rules, in a few instances, we shall give their demonstrations.

In all practical applications of mathematics it is necessary to express magnitudes of every kind by numbers. For this purpose a line of some determinate length, as one inch, one foot, &c. is assumed as the measuring unit of lines, and the number expressing how often this unit is contained in any line, is the numerical value or measure of that line.

A surface of some determinate figure and magnitude is assumed as the measuring unit of surfaces, and the number of units contained in any surface is the numerical measure of that surface, and is called its *area*. It is usual to assume, as the measuring unit of surfaces, a square, whose side is the measuring unit of lines.

A solid of a determinate figure and magnitude is in like manner assumed as the measuring unit of solids, and the number of units contained in any solid is its solidity or content. The unit of solids is a cube, each of whose edges is the measuring unit of lines, and consequently each of its faces the measuring unit of surfaces.

A right angle is conceived to be divided into 90 equal angles; and one of these, called an angle of one degree, is assumed as the measuring unit of angles.

The measures generally employed in the application of mensuration to the common affairs of life, and their proportions to each other, are expressed in the following tables.

Table of Lineal Measures.

12 Inches	=	1 Foot.
3 Feet	=	1 Yard.
6 Feet	=	1 Fathom.
$5\frac{1}{2}$ Yards	=	1 Pole, Rod, or Perch.
40 Poles	=	1 Furlong.
8 Furlongs	=	1 Mile.
3 Miles	=	1 League.
$69\frac{1}{6}$ Miles nearly	=	1 Degree.
360 Degrees	=	The earth's circumference.

Note. An inch is supposed equal to three barley-corns in length.

4 Inches	=	1 Hand, or handsbreadth.
5 Feet	=	1 Geometrical Pace.
4 Poles or 66 Feet 100 Links each $7\frac{92}{100}$ Inches	=	1 English chain.
74 Feet	=	1 Scots chain.

Table of Square Measures.

144 Square Inches	=	1 Foot square.
9 Square feet	=	1 Yard.
$30\frac{1}{4}$ Square Yards	=	1 Pole.
40 Square Poles	=	1 Rood.
4 Roods or 160 Square Poles	=	1 Acre.
10 Square Chains or 100,000 Square Links	=	1 Acre.
640 Square Acres	=	1 Square Mile.

Note. The Scots acre is to the English acre as 100,000 to 78,694.

Table of Solid Measures.

1728 Cubic Inches	=	1 Cubic Foot.
27 Cubic Feet	=	1 Cubic Yard.

Note,	282 Cubic inches make	1 Ale Gallon.
	231	1 Wine Gallon.
	2150.42	a Winchester Bushel.
	105 Cubic inches	1 Scots Pint.
	The Wheat Firlot contains	$21\frac{1}{4}$ Scots Pints.
	The Barley Firlot	31 Scots Pints.

SECTION I.

OF THE MENSURATION OF RIGHT LINES AND ANGLES.

Of Right Lines and Angles.

THE rules by which certain of the sides or angles of a triangle are to be found, when other sides and angles are given, might be considered as belonging to this part of mensuration. But as these are fully investigated and explained in the article PLANE TRIGONOMETRY, it is not necessary to deliver them also here. Referring therefore to that article, we shall employ the remainder of this section in the application of trigonometry to the mensuration of heights and distances.

Mensuration of Heights and Distances.

By the application of geometry the measurement of lines, which, on account of their position or other circumstances, are inaccessible, is reduced to the determination of angles, and of other lines which are accessible, and admit of being measured by methods sufficiently obvious.

A line considered as traced on the ground may be measured with rods or a Gunter's chain of 66 feet; but more expeditiously with measuring tapes of 50 or 100 feet. By these, if the ground be tolerably even, and the direction of the line be traced pretty correctly, a distance may, by using proper care, be measured within about 3 inches of the truth in every 50 feet, so that the error may not exceed the 200th part of the whole line.

Vertical angles may be measured with a quadrant furnished with a plummet and sights in the manner indicated by fig. 1. and fig. 2. If an angle of elevation is to be measured, as the angle contained by a horizontal line AC, and a line drawn from A to B the top of a tower, hill, or other eminence; or to a celestial body, as a star, &c.; the centre of the quadrant must be fixed at A, and the instrument moved about A, in the vertical plane, till to an eye placed at G the object B be seen through the two sights D, *d*. Then will the arch EF, cut off by the plumb-line AF, be the measure of the angle CAB. Plate CCCXXXII.

An angle of depression CAB (fig. 2.) is to be measured exactly in the same manner, except that here the

 eye

eye is to be placed at A the centre of the instrument, and the measure of the angle is the arch EF.

But the most convenient instrument of any for observing angles, whether vertical or horizontal, is the *Theodolite*. This instrument is variously constructed, so as to admit of being sold at a higher or lower price, according to the degree of accuracy the purchaser may wish to attain in his observations with it. An instrument of this kind is represented in fig. 3. Its principal parts are, 1. A telescope and its level CC, D. 2. The vertical arc BB. 3. The horizontal limb and compass AA. The limb is generally about 7 inches in diameter. 4. The staff with its parallel plates E.

The telescope CC in the best instruments is generally of the achromatic kind, in order to obtain a larger field and greater magnifying power. In the focus of the eye glass are two very fine hairs or wires, at right angles to each other, whose intersection is in the plane of the vertical arc. The object glass may be moved to different distances from the eye glass by turning the milled nut *a*, and thus may be accommodated to the eye of the observer and distance of the object. The screws for moving and adjusting the cross hairs, are sunk a little within the eye tube. On the outside of the telescope are two metal rings which are ground perfectly true. These are to lie on the supporters *e*, *e*, called Y's, which are fixed to the vertical arc. The vertical arc BB is firmly fixed to a long axis which is at right angles to the plane of the arc. This axis is sustained by, and moveable on, the two supporters, which are fixed firmly to the horizontal plate. On the upper part of the vertical arc are the two Y's for holding the telescope; the inner sides of these are so framed as to be tangents to the cylindric rings of the telescope, and therefore bear only on one part. The telescope is confined to the Y's by two loops which turn on a joint, and may therefore be readily opened and turned back when the two pins are taken out.

One side of the vertical arc is graduated to half degrees, which are subdivided to every minute of a degree by a *nonius*. It is numbered each way; from 0 to 90° towards the eye end for angles of altitude, and from 0 to 50° towards the object end for angles of depression. On the other side of the vertical arc are two ranges of divisions, one for taking the upright height of timber in 100th parts of the distance between the instrument and tree whose height is to be measured; and the other for reducing hypothenusal lines to such as are horizontal.

The vertical arc is cut with teeth or a rack, and may be moved regularly, and with ease, by turning the milled nut *b*.

The compass is fixed to the upper horizontal plate, its ring is divided into 360°, and the bottom of the box is divided into four parts or quadrants, each of which is subdivided to every 10°. The magnetic needle is supported in the middle of the box upon a steel pin finely pointed, and there is a wire trigger for throwing the needle off the point when not in use.

The horizontal limb AA consists of two plates, one moveable on the other, the outermost edge of the upper plate is chamfered to serve as an index to the degrees on the lower. The upper plate, together with the compass, vertical arc, and telescope, are easily turned round by a pinion fixed to the screw *c*; *d* is a nut for fixing the index to any part of the limb, and thereby rendering it secure, while the instrument is moved from one station to another. The horizontal limb is divided into half degrees, and numbered from the right hand towards the left; the divisions are subdivided by the nonius scale to every minute of a degree.

On the upper plate, towards the nonius, are a few divisions similar to those on the vertical arc, giving the 100th parts, for measuring the diameter of trees, buildings, &c.

The whole instrument fits on the conical ferril of a strong brass-headed staff, with three substantial wooden legs. The top or head of the staff consists of two brass plates E, parallel to each other: four screws pass through the upper plate and rest on the lower plate; by the action of these the horizontal limb may be set truly level, and for this purpose a strong pin is fixed to the outside of the plate, and connected with a ball that fits into a socket in the lower plate; the axis of the pin and ball are so framed as to be perpendicular to the plate, and consequently to the horizontal limb.

There are three adjustments necessary before the instrument is applied to the mensuration of angles. In the first place, care must be taken that the line of collimation (that is, the line of vision passing through the cross hairs) be exactly in the centre of the cylindric rings round the telescope; in the next place, that the level be parallel to this line; and, lastly, the horizontal limb must be so set, that when the vertical arc is at *zero*, and the upper part moved round, the bubble of the level will remain in the middle of the open space.

When these adjustments are made, and the instrument is to be applied to practice, the lower plate of the horizontal limb AA being supposed to remain unmoved and parallel to the horizon, the telescope is to be directed successively to the different objects, whose angular positions are to be determined, by means of the pinions at *c* and *b*; (the former of which turns the upper part of the instrument round in a horizontal plane, and the latter turns the arc BB in a vertical plane). Then, the angle which a line passing through the axis of the telescope and any object makes with the horizon, will be indicated by the arc of the vertical circle between 0° and the index engraved on the nonius scale H fixed to the upper plate of the horizontal limb of the instrument. Also, the horizontal angle contained by two vertical planes conceived to pass through any two objects and the centre of the instrument, will be shewn by the arc of the lower plate of the horizontal limb over which the index engraved on the upper plate has passed by the direction of the telescope being changed from the one object to the other.

Having thus explained shortly the nature of the instruments by which accessible lines and angles are to be measured, and the manner of applying them, we shall now show, by a few examples, how to find from these other lines which cannot be determined by a direct measurement.

Example 1. Having measured AE, a distance of 200 feet in a direct horizontal line from the bottom of a tower, the angle BCD, contained by the horizontal line CD: and a line drawn from C to the top of the tower, Fig. 4.

Of Right Lines and Angles.

tower, was measured by a quadrant, or theodolite placed at C, and found to be 47° 30′. The centre C of the instrument was five feet above the line AE at its extremity E. It is required hence to determine AB the height of the tower.

In the right-angled triangle CBD we have given the side CD=200 feet, and the angle C=47° 30′. And since by the rules of PLANE TRIGONOMETRY,

rad. : tan. BCD :: DC : DB;

By employing the logarithmic tables (see LOGARITHMS), and proceeding as is taught in PLANE TRIGONOMETRY, we shall find DB=218.3 feet. To which add DA=EC=5 feet, the height of the instrument, and we have AB=223.3 feet, the height of the tower.

Fig. 5. *Ex.* 2. Suppose a cloud, or balloon C, is seen at the same time by two observers at A and B, and that these stations are in the same vertical plane with the object C, and on the same side of it. Also suppose that its angles of elevation, viz. the angles A and B are 35° and 64°, and that AB, the distance between the observers, is 880 feet. It is required hence to determine CD the height of the object, also AC, BC its distances from the two observers.

In the triangle CAB there are given the outward angle CBD=64°, and one of the inward angles A=35°; hence the other inward angle ACB, which is their difference, is given, and =64°−35°=29°.

Now in the triangle CAB

Sin. ACB : sin. A :: AB : BC,
and sin. ACB : sin. B :: AB : AC.

From these proportions, by actual calculation, BC will be found =1041 feet, and AC=1631 feet.

Again, in the right-angled triangle BCD

rad. : sin. B :: BC : CD.

Hence CD will be found =936 feet.

Fig. 6. *Ex.* 3. Wanting to know the breadth CD of a river, and also the distance of an object A close by its side from another object C on its opposite side, a base AB of 400 yards was measured along the bank. Then, by means of a theodolite, the angles CBA and CAB were measured, and found to be 37° 40′ and 59° 15′ respectively. It is required thence to determine the breadth CD, and the distance AC between the objects A and C.

This example differs from the last only by the given angles, and distances required, lying in a horizontal instead of a vertical plane.

In the triangle ABC we have the base AB, also the angles A and B, and consequently the angle C given. And by Plane Trigonometry,

Sin. ACB : sin. B :: AB : AC.

Hence AC is found to be 246.2 yards.

Also, in the right-angled triangle ACD,

rad. : sin. A :: AC : CD.

Hence CD is found to be 211.6 yards.

Of Right Lines and Angles.

Ex. 4. At B the top of a tower which stood on a hill near the sea shore, the angle of depression of a ship at anchor (viz. the angle HBS), was 4° 52′; and at R, the bottom of the tower, its depression (namely, the angle NRS) was 4° 2′. Required AS the horizontal distance of the vessel: and also RA, the height of the bottom of the tower above the level of the sea, supposing RB the height of the tower itself to be 54 feet. Fig. 7.

From the angle BSA=HBS=4° 52′, subtract the angle RSA=NRS=4° 2′, and there remains the angle BSR=50′. Also, from the angle HBA=90° subtract HBS=4° 52′, and there remains SBR=85° 8′.

In the triangle SBR,

Sin. BSR : sin. SBR :: BR : SR;

Hence SR is found. Again, in the triangle SRA,

rad. : sin. RSA :: SR : AR,
and rad. : cos. RSA :: SR : AS.

From the first of these proportions we find AR=260 feet; and from the second, AS=3690 feet.

Ex. 5. To measure the height of an obelisk CD, standing on the top of a declivity, two stations at A and B were taken, one at the distance of 40, and the other at the distance of 100 feet from the centre of its base, which was in a straight line with the stations. At the nearer station A, a line drawn from it to the top of the obelisk was found to make an angle of 41° with the plane of the declivity; and at B, the more remote station, the like angle was found to be 23° 45′. Hence it is required to find the height of the obelisk. Fig. 8.

From the angle CAD=41°, subtract the angle B=23° 45′, and there remains the angle BCA=17° 15′.

In the triangle BCA,

Sin. BCA : sin. B :. AB : AC. Hence AC=81.49 feet.

And in the triangle ACD,

AC+AD : AC−AD :: tan. $\frac{1}{2}$(D+C) : tan. $\frac{1}{2}$(D−C).

Hence $\frac{1}{2}$(D−C)=40° 24′$\frac{1}{2}$, which, subtracted from $\frac{1}{2}$(D+C), gives the angle ACD=27° 5′$\frac{1}{2}$.

Lastly, in the triangle ACD,

Sin. ACD : sin. A :: AD : DC.

Hence DC, the height required, will be found to be 57.62 feet.

Ex. 6. Wanting to know the distance between two inaccessible objects H and M, a base AB of 670 yards was measured in the same plane with the objects, and the following angles were taken at its extremities. Fig. 9.

At A $\begin{cases} \text{BAM}=40^\circ\ 16' \\ \text{MAH}=57\ \ 40 \end{cases}$ At B $\begin{cases} \text{ABH}=42^\circ\ 22' \\ \text{HBM}=71\ \ 7 \end{cases}$

Hence it is required to determine HM, the distance between the objects.

In the triangle HAB we have the angle HBA=42° 22′, the angle HAB (=HAM+MAB)=97°

$97^\circ\ 56'$, and therefore the remaining angle AHB $=39^\circ\ 42'$. We have also the side AB $=670$ yards. Hence, by this proportion,

Sin. AHB : sin. HBA :: AB : AH.

we find AH$=706.8$ yards.

Again, in the triangle MAB we have the angle MAB$=40^\circ\ 16'$, the angle ABM ($=$ABH$+$HBM) $=113^\circ\ 29'$, and therefore the angle AMB$=26^\circ\ 15'$. Hence from the proportion,

Sin. AMB : sin. ABM :: AB : AM

we get AM$=1389.4$.

In the triangle HAM, besides the angle HAM$=57^\circ\ 40'$ we have now the sides AH $=706.8$, and AM$=1389.4$ yards, to find the remaining side HM. Therefore, proceeding according to the rules of trigonometry, we state this proportion,

AM$+$AH : AM$-$AH :: tan. $\frac{1}{2}$(AHM$+$AMH) : tan. $\frac{1}{2}$(AHM$-$AMH.)

Hence we find half the difference of the angles AHM and AMH to be $30^\circ\ 36'$, which taken from $61^\circ\ 10'$, half the sum, leaves $30^\circ\ 34'$ for AMH the least of the two angles. Lastly, from the proportion

Sin. HMA : sin. HAM :: HA : HM,

we get HM $=1174$ yards, the answer to the question.

Fig. 10. *Ex.* 7. There are three objects A, B, C, whose distances asunder are known to be as follows; namely, from A to B $106\frac{1}{2}$, from A to C 202, and from B to C 131 fathoms. Now to determine the distance of D a fourth object, or station, from each of the other three, the angle ADB was measured with a theodolite, or other suitable instrument; and found to be $13^\circ\ 30'$, and the angle CDB was found $29^\circ\ 50'$. Hence it is required to determine the distances DA, DB, and DC, supposing DB the least of the three.

Let a circle be described about the points A, D, and C; and let DB be produced to meet the circle again in E, and draw AE, CE.

In the triangle AEC there are given the side AC$=$ 202 fathoms, the angle ACE ($=$ADE. Geom. Sect. II. Theor. 15.) $=13^\circ\ 30'$, and the angle CAE ($=$ CDE)$=29^\circ\ 50'$. Hence (by Trigon.) we shall have AE$=68.716$ fathoms.

In the triangle ABC, all its sides are given, and hence the angle BAC will be found $=35^\circ\ 35'\ 54''$; to this, add the angle CAE, and the sum is the angle EAB$=65^\circ\ 25'\ 54''$.

In the triangle ABE, we have given AB$=106.5$, AE$=68.716$, the angle BAE$=65^\circ\ 25'\ 54''$; hence we shall have the angle ABE$=38^\circ\ 43'\ 41''$, and the angle AEB$=75^\circ\ 51'\ 25''$.

In the triangle ADE we have the side AE$=68.716$, the angle ADE$=13^\circ\ 30'$, and the angle AED$=75^\circ\ 51'\ 25''$. Hence we have AD$=285.43$ fathoms, which is one of the distances required.

In the triangle ABD we have AB$=106.5$, the angle ADB$=13^\circ\ 30'$, the angle DAB ($=$ABE$-$ADB) $25^\circ\ 13'\ 45''$. Hence BD, another of the distances sought, will be found $=194.45$ fathoms.

Lastly, In the triangle ADC, there is given AC$=$ 202, the angle ADC ($=$ADB$+$BDC) $=43^\circ\ 20'$, the angle DCA ($=$DEA) $=75^\circ\ 15'\ 25''$. Hence we get DC$=256.97$ fathoms, which is the remaining distance sought.

Ex. 8. From a ship at sea a point of land was observed to bear E. by S.; and after sailing N. E. 12 miles, the same point was found to bear S. E. by E. How far was the last observation made from the point of land? Fig. 11.

Let A be the first position of the ship, B the second, and C the point of land. In the triangle ABC we have given the angle A$=5$ points or $56^\circ\ 15'$, the angle B$=9$ points, or $101^\circ\ 15'$, and the angle C$=2$ points or $22^\circ\ 30'$. Also the side AB$=12$ miles. Hence (by Trigon.) the side BC is readily found to be 26.073 miles.

There are various other instruments and methods by which the heights or distances of objects may be found. One of the most simple instruments, both in respect of its construction and application, is a square, ABCD, made of some solid material, and furnished with two sights on AB, one of its edges, and a plummet fastened to A, one of its angles, and having the two sides BC, CD, which contain the opposite angle divided into 10, or 100, or 1000 equal parts. Fig. 12.

To measure any altitude HK with this instrument. Let it be held in such a position that K, the top of the object may be seen through the sights on its edge AB, while its plane is perpendicular to the horizon; then the plummet will cut off from the square a triangle similar to that formed by the horizontal line AI, the vertical line IK, and the line AK drawn from the eye to the top of the object. Fig. 13.

If the line of the plummet pass through D the opposite angle of the square, then the height KI will be equal to AI, the distance of the eye from the vertical line to be measured. If it meet AD, the side of the square next the eye, in some point E between A and D, then the triangles ABE, AIK, being similar, and the angle ABE equal to the angle AKI, we have AE : AB :: AI : IK. Let us now suppose AD$=$ AB to be divided into 1000 equal parts; then the length of AE will be expressed by a certain number of these parts; thus the proportion of AE to AB, and consequently that of AI to IK will be given; therefore if AI be determined by actual measurement, we may from the above proportion immediately find IK.

If again the line of the plummet meet DC the side of the square opposite to the sights in F, then, in the similar triangles AIK, BCF, the angle AKI is equal to BFC; thus we have BC : CF :: AI : IK. Hence IK is determined as before, and in each case by adding HI the height of the eye, we shall have HK the whole height required.

SECTION II.

MENSURATION OF PLANE FIGURES.

Problem I.

To find the area of a parallelogram, whether it be a square, a rectangle, a rhombus, or a rhomboid.

Of Plane Figures.

Rule I.

Multiply the length by the perpendicular breadth, and the product will be the area.

This rule is demonstrated in Geometry, Sect. IV. Theor. 5.

Fig. 14. *Ex.* 1. Required the area of a square ABCD, whose side AB is $10\frac{1}{2}$ inches.

Here $10\frac{1}{2} \times 10\frac{1}{2}$ or $10.5 \times 10.5 = 110.25$ square inches is the area required.

Fig. 15. *Ex.* 2. Required the area of a rectangle EFGH, whose length EF is 13.75 chains, and breadth FG is 9.5 chains.

Here $13.75 \times 9.5 = 130.625$ square chains is the area, which, when reduced to acres, &c. is 13 *ac.* 0 *ro.* 10 *po.*

Fig. 16. *Ex.* 3. Required the area of a parallelogram KLMN, whose length KL is 37 feet, and perpendicular breadth NO is $5\frac{1}{4}$ or 5.25 feet.

In this example the area is $37 \times 5.25 = 194.25$ square feet, or 21.583 square yards.

Rule II.

As radius,
To the sine of any angle of the parallelogram,
So is the product of the sides including the angle,
To the area of the parallelogram.

To see the reason of this rule it is only necessary to observe, that in the parallelogram KLMN, the perpendicular breadth NO is a fourth proportional to *radius*, *sine* of the angle K, and the oblique line KN, (Trigonometry), and is therefore equal to $\frac{sin.\ K}{rad.} \times KN$; therefore the area of the figure is $\frac{sin.\ K}{rad.} \times KN \times KL$, which expression is the same as the result obtained by the above rule.

Ex. Suppose the sides KL and KN are 36 feet, and 25.5 feet, and the angle K is 58°, required the area.

Here it will be convenient to employ the table of logarithms given at the end of the article Logarithms. The operation may stand thus,

log. rad.	10.00000
log. sin. 58°	9.92842
log. (36×25.5) = log. 36 + log. 25.5.	2.96284
log. of area	2.89126

area = 778.5 square feet.

Problem II.

Having given any two sides of a right-angled triangle, to find the remaining side.

Rule.

1. When the sides about the right angle are given, to find the hypothenuse.

Add together the squares of the sides about the right angle, and the square root of the sum will be the hypothenuse.

2. When the hypothenuse and one of the sides about the right angle is given, to find the other side.

From the square of the hypothenuse subtract the square of the given side, and the square root of the remainder will be the other side.

This rule is deduced from Theor. 13. Sect. IV. Geometry.

Fig. 17. *Example* 1. In a right-angled triangle ABC, the sides AB and AC, about the right angle, are 33 feet and 56 feet; what is the length of the hypothenuse BC?

Here $33^2 + 56^2 = 3136 + 1089 = 4225$,
and $\sqrt{(4225)} = 65$ feet, = the hypothenuse BC.

Ex. 2. Suppose the hypothenuse BC to be 65 feet, and AB one of the sides about the right angle to be 33 feet; what is the length of AC the other side?

Here $65^2 - 33^2 = 4225 - 1089 = 3136$;
and $\sqrt{(3316)} = 56$ feet = the side AC.

Problem III.

To find the area of a triangle.

Rule I.

Multiply any one of its sides by the perpendicular let fall upon it from the opposite angle, and half the product will be the area.

The truth of this rule is proved in Geometry, Sect. IV. Theor. 6.

Example. What is the area of a triangle ABC, whose base AC is 40, and perpendicular BD is 14.52 chains?

Fig. 18. The product of the base by the perpendicular, or 40×14.52, is 580.8 square chains, the half of which, or 290.4 *sq. ch.* = 29 *ac.* 0 *r.* 6.4 *po.* is the area of the triangle.

Rule II.

As radius,
To the sine of any angle of a triangle,
So is the product of the sides including the angle,
To twice the area of the triangle.

This rule follows immediately from the second rule of Prob. I. by considering that the triangle KNL (fig. 16.) is half the parallelogram KNML.

Fig. 19. *Example.* What is the area of a triangle ABC, whose two sides AB and AC are 30 and 40, and the included angle A is 28° 57′?

Operation by Logarithms.

log. rad.	10.00000
log. (30×40) = log. 30 + log. 40.	3.07918
log. sin. 28° 57′	9.68489
log. of twice area	2.76407

twice area = 580.85
area 290.42

Rule

Of Plane Figures.

Rule III.

When the three sides are given, add together the three sides, and take half the sum. Next, subtract each side severally from the said half sum, thus obtaining three remainders. Lastly, multiply the said half sum, and those three remainders all together, and extract the square root of the last product for the area of the triangle.

This practical rule is deduced from the following geometrical theorem. *The area of a triangle is a mean proportional between two rectangles, one of which is contained by half the perimeter of the triangle, and the excess of half the perimeter above any one of its sides; and the other is contained by the excesses of half the perimeter above each of the other two sides.* As this theorem is not only remarkable, but also of great utility in mensuration, we shall here give its demonstration.

Fig. 9.

Let ABC then be any triangle; produce AB, any one of its sides, and take BD, and B d, each equal to BC; join CD and Cd, and through A draw a line parallel to BC, meeting CD and C d produced in E and e; thus the angle AED will be equal to the angle BCD, (Geometry, Sect. I. Theor. 21.), that is, to the angle BDC or ADC, (Sect. I. Theor. 11.); and hence AE=AD (Sect. I. Theor. 12.); and in like manner, because the angle A e d is equal to the angle BC d, that is, to the angle B dC, or A de, therefore A e=A d.

On A as a centre, at the distance AD or AE, describe a circle meeting AC in F and G; and on the same centre, with the distance A d or A e, describe another circle meeting AC in f and g, and draw BH and B h perpendicular to CD and C d. Then, because BD, BC, B d are equal, the point C is in the circumference of a circle, of which D d is the diameter, therefore CD and C d are bisected at H and h (Sect. II. Theor. 6.) and the angle DC d is a right angle, (Sect. II. Theor. 17.), and hence the figure CHB h is a rectangle, so that B h = CH = $\frac{1}{2}$ CD, and BH=Ch= $\frac{1}{2}$ C d.

Join BE, and B e, then the triangle BAC is equal to each of the triangles BEC, B e C (Sect. IV. Theor. 2. Cor. 2.); but the triangle BEC is equal to $\frac{1}{2}$ EC × BH (Sect. IV. Theor. 2.), that is to $\frac{1}{4}$ EC × C d; and in like manner the triangle B e C is equal to $\frac{1}{2}$ e C × B h, that is to $\frac{1}{4}$ e C × CD, therefore the triangle ABC is equal to $\frac{1}{4}$ EC × C d, and also to $\frac{1}{4}$ e C × CD.

$$\left.\begin{array}{l}\text{Now since CD} : \text{C}d :: \text{CE}\times\text{CD} : \text{CE}\times\text{C}d \\ \text{and also CD} : \text{C}d :: \text{C}e\times\text{CD} : \text{C}e\times\text{C}d\end{array}\right\}\begin{array}{l}\text{Sect. IV.}\\ \text{Theor. 3.}\end{array}$$

Therefore CE × CD : CE × C d :: C e × CD : Ce × Cd; that is, because CE × CD=FC × CG, and C e × C d= fC × C g (Sect. IV. Corollaries to Theor. 28. and 29.),

$$\text{FC}\times\text{CG} : \text{CE}\times\text{C}d :: \text{C}e\times\text{CD} : f\text{C}\times\text{C}g;$$

which last proportion (by taking one-fourth of each of its terms, and substituting the triangle ABC for its equivalent values $\frac{1}{4}$ CE × C d and $\frac{1}{4}$ C e × CD) gives us

$$\tfrac{1}{2}\text{FC}\times\tfrac{1}{2}\text{CG} : \textit{trian.}\,\text{ABC} :: \textit{trian.}\,\text{ABC} : \tfrac{1}{2}f\text{C}\times\tfrac{1}{2}\text{C}g.$$

Now, if it be considered that the radius of the circle g d e is AB—BC, it will readily appear that, putting $2s$ for the perimeter of the triangle ABC, we have

$$\begin{array}{l} \text{FC}\ (=\text{AB}+\ \ \text{BC}\ +\text{AC}) = 2s \\ \text{CG}\ (=\text{AB}+\ \ \text{BC}\ -\text{AC}) = 2s-2\,\text{AC}, \\ f\,\text{C}\ (=\text{AC}+\left\{\text{AB}-\text{BC}\right\}) = 2s-2\,\text{BC}, \\ g\,\text{C}\ (=\text{AC}-\left\{\text{AB}-\text{BC}\right\}) = 2s-2\,\text{AB}. \end{array}$$

Put now a, b, c for the sides AC, BC, and AB respectively, then $\frac{1}{2}$ FC=s, $\frac{1}{2}$ GC=$s-a$, $\frac{1}{2}$ fC=$s-b$, $\frac{1}{2}$C g =$s-c$; thus the last proportion becomes

$$s\times(s-a) : \textit{trian.}\,\text{ABC} :: \textit{trian.}\,\text{ABC} : (s-b)\times(s-c),$$

which conclusion, when expressed in words at length, is evidently the proportion to be demonstrated.

And as a mean proportional between two quantities is found by taking the square root of the product, it follows that the area of the triangle ABC, which is a mean between $s\times(s-a)$ and $(s-b)\times(s-c)$, is equal to

$$\sqrt{\left\{ s\times(s-a)\times(s-b)\times(s-c) \right\}}$$

which formula, when expressed in words at length, gives the preceding rule.

Example. Required the area of a triangle whose three sides are 24, 36, and 48 chains respectively.

Here 24+36+48=108 = the sum of the three sides.

And $\frac{108}{2}$=54= half that sum.

Also 54 — 24 = 30, the first remainder; 54—36= 18, the second remainder; and 54—48=6, the third remainder.

The product of the half sum and remainders is

$$54\times30\times18\times6=174960.$$

And the square root of this product is

$\sqrt{(174960)}$=418.28 sq. ch. the area required.

Problem IV.

To find the area of a trapezoid.

Rule.

Add together the two parallel sides, then multiply their sum by the perpendicular breadth, or distance between them, and half the product will be the area.

This rule is demonstrated in Geometry, Sect. IV. Theor. 7.

Example. Required the area of the trapezoid AB CD, whose parallel sides AB and DC are 7.5. and 12.25 chains, and perpendicular breadth DE is 15.4 chains. Fig. 10.

The sum of the parallel sides is 7.5+12.25=19.75; which multiplied by the breadth is

$$19.75\times15.4=304.15;$$

and half this product is

$\frac{304.15}{2}$=152.075 *sq. ch.* = 15 *ac.* 33.2 *po.*

the area required.

Problem

Of Plane Figures.

PROBLEM V.

To find the area of any trapezium.

RULE.

Divide the trapezium into two triangles by a diagonal, then find the areas of these triangles, and add them together.

Note If two perpendiculars be let fall on the diagonal from the other two opposite angles, the sum of these perpendiculars being multiplied by the diagonal, half the product will be the area of the trapezium. The reason of this rule is sufficiently obvious.

Fig. 21. *Example.* In the trapezium ABCD the diagonal AC is 42, and the two perpendiculars BE, DF are 16 and 18: What is its area?

Here the sum of the perp. is $16+18=34$, which multiplied by 42, and divided by 2 gives

$$\frac{34\times 42}{2}=714 \text{ the area.}$$

PROBLEM VI.

To find the area of an irregular polygon.

RULE.

Draw diagonals dividing the proposed polygon into trapeziums and triangles; then find the areas of all these separately, and add them together for the content of the whole polygon. The reason of this rule, and the manner of applying it, are sufficiently obvious.

PROBLEM VII.

To find the area of a regular polygon.

RULE.

Multiply the perimeter of the polygon, or sum of its sides, by the perpendicular drawn from its centre on one of its sides, and take half the product for the area.

This rule is only in effect resolving the polygon into as many triangles as it has sides, by drawing lines from its centre to all its angles, then taking the sum of their areas for the area of the figure.

Fig. 22. *Example.* Required the area of a regular pentagon ABCDE, whose side AB, or BC, &c. is 25 feet, and perpendicular HK is 17.2 feet.

Here $25\times 5=125=$ the perimeter,
And $125=17.2=2150$,
And its half $1075=$ the area required.

Note. If only the side of the polygon be given, its perpendicular may be found by the following proportion.

As radius,
To the tan. of half the angle of the polygon,
So is half the side of the polygon,
To the perpendicular.

And here, as well as in all other trigonometrical calculations, we may employ the table of logarithmic sines and tangents given in the article LOGARITHMS.

The angle of the polygon, that is, the angle contained by any two of its adjacent sides, will be found from this theorem. *The sum of all its interior angles is equal to twice as many right angles, wanting four, as it has sides*, which is demonstrated in Theor. 25. Sect. I. GEOMETRY.

PROBLEM VIII.

To find the diameter and circumference of a circle, the one from the other.

RULE I

As 7 is to 22, so is the diameter to the circumference, nearly.

As 22 is to 7, so is the circumference to the diameter, nearly.

RULE II.

As 113 is to 355, so is the diameter to the circumference, nearly.

As 355 is to 113, so is the circumference to the diameter, nearly.

RULE III.

As 1 is to 3.1416, so is the diameter to the circumference, nearly.

As 3.1416 is to 1, so is the circumference to the diameter, nearly.

Note. The result obtained by the first rule, which is the least accurate of the three, will not differ from the true answer by so much as its 2400th part. But that obtained by the second rule, which is the most accurate, will not differ by so much as its 10000000th part.

The proportion of the diameter of a circle to its circumference is investigated in GEOMETRY, Sect. VI. Prop. 6. Also in FLUXIONS, § 137 and § 140. The manner of finding the first and second rules, and others of the same kind, is explained in ALGEBRA, Sect. XXI. But it is impossible to express exactly, by finite numbers, the proportion of the diameter of the circle to its circumference.

Example. 1. To find the circumference of a circle whose diameter is 20.

By the first rule,

$$7 : 22 :: 20 : \frac{20\times 22}{7}=62\tfrac{6}{7} \text{ the answer.}$$

Or by the third rule $3.1416\times 20=62.832$ the answer.

Ex. 2. The circumference of a circle is 10 feet, what is its diameter?

By the second rule,

$$355 : 113 :: 10 : \frac{113\times 10}{355}=3.1831 \text{ the answer.}$$

PROBLEM IX.

To find the length of any arch of a circle.

RULE I.

As 180 is to the number of degrees in the arch, so is 3.1416 times the radius to its length.

To see the reason of this rule it is only necessary to consider, that 3.1416 times the radius is (by last rule) equal to half the circumference, or to an arch of 180°, and that the length of an arch is proportional to the number of degrees it contains.

Example.

Fig. 3. *Example.* Required the length of the arch AEB, whose chord AB is 6, the radius AC or CB being 9. Draw CD perpendicular to the chord, then CD will bisect the chord in D, and the arch in E. Now in the right-angled triangle ACD, there is given the hypothenuse AC=9, and the side AD=3; hence, by trigonometry, the angle ACE will be found to contain $19^{\circ}\ 28'\ \frac{3}{10}=19.471$ degrees. The double of this, or 38.942, is the number of degrees in the whole arch AEB. Then by the rule

$$180 : 38.942 :: 9 \times 3.1416 : \frac{9 \times 3.1416 \times 38.942}{180}$$

$=6.11701$ the answer.

Rule II.

From 8 times the chord of half the arch subtract the chord of the whole arch, and $\frac{1}{3}$ of the remainder will be the length of the arch nearly.

This rule may be demonstrated briefly thus. Let a denote an arch of a circle; then from the series expressing the sine of an arch in terms of the arch, (see Fluxions, § 70. *Ex.* 3. also Trigonometry) we have, putting rad. $=1$,

$$\text{Sin. } \tfrac{1}{2}a=\tfrac{1}{2}a-\frac{a^3}{48}+\frac{a^5}{3840}-, \text{\&c.}$$

Therefore, if the arch a be small, so that a^5 is a very small quantity, then

$$\text{Sin. } \tfrac{1}{2}a=\tfrac{1}{2}a-\frac{a^3}{48} \text{ nearly.}$$

In like manner we have

$$\text{Sin. } \tfrac{1}{4}a=\tfrac{1}{4}a-\frac{a^3}{384} \text{ nearly.}$$

By means of the two last equations exterminate the quantity a^3, and the resulting equation is

$$16 \text{ sin. } \tfrac{1}{4}a-2 \text{ sin. } \tfrac{1}{2}a=3\,a.$$

But 16 sin. $\frac{1}{4}a=8$ chord $\frac{1}{2}a$, and 2 sin. $\frac{1}{2}a=$ chord a.

Therefore 8 chord $\frac{1}{2}a-$ chord $a=3\,a$.

Here we have supposed the radius of the circle to be unity; but the same must evidently be true, whatever be the radius of the circle.

Fig. 3. *Example.* Suppose as before, that the chord AB is 6, and the radius AC is 9. Then $CD=\sqrt{(CA^2-AD^2)}=\sqrt{72}=8.4852814$, and $DE=9-8.4852814=0.5147186$,

and hence $AE=\sqrt{(AD^2+DE^2)}=3.043836$.

Then by the rule

$$\frac{3.043836 \times 8-6}{3}=6.116896$$

is the length of the arch, nearly the same as before.

Problem X.

To find the area of a circle.

Rule I.

Multiply half the circumference by half the diameter, and the product will be the area.

Rule II.

Multiply the square of the diameter by .7854, and the product will be the area.

The first of these rules has been demonstrated in Geometry, Sect. VI. Prop. 3. And the second rule is deduced from the first, as follows. It appears from Prop. 6. Sect. VI. Geometry, that the diameter of a circle being unity, its circumference is 3.1416 nearly; therefore, by the first rule, its area is $1 \times 3.1416 \div 4=.7854$. But circles are to one another as the squares of their diameters, (Prop. 4.) therefore, putting d for the diameter of any circle, $1 : d^2 :: .7854 : .7854\,d^2$ = the area of the circle whose diameter is d.

Example. What is the area of a circle whose diameter is 7.

By the second rule $7 \times 7 \times .7854=38.4846$ the area.

By the first rule $7 \times 3.1416=$ the circumference.

Then $\frac{7 \times 3.1416 \times 7}{4}=7 \times 7 \times .7854$ the area, the same as before.

Problem XI.

To find the area of any sector of a circle.

Rule I.

Multiply the radius by half the arch of the sector, and the product will be the area, as in the whole circle.

Rule II.

As 360 is to the degrees in the arc of the sector, so is the area of the whole circle to the area of the sector.

The first of these rules follows easily from the rule for the whole area, by considering that the whole circumference is to the arch of the sector, as the whole area to the area of the sector, that is,

circum. : arch of sect. :: rad. $\times \frac{1}{2}$ circum. : area of sect.

Hence area of sect. = rad. $\times \frac{1}{2}$ arch of sect.

The second rule is too obvious to need any formal proof.

Example. To find the area of a circular sector ACB whose arch AEB contains 18 degrees, the diameter being 3 feet. Fig. 23.

1. By the first rule.

First $3.1416 \times 3=9.4248$ the circum.

And $360 : 18 :: 9.4248 : .47124$ the arch of sect.

Then $.47124 \times 3 \div 4=.35343$ the area.

2. By the second rule.

First $.7854 \times 3^2=7.0686$ the area of the circle.

Then $360 : 18 :: 7.0686 : .35343$ the area.

Problem

Of Plane Figures.

Problem XII.

To find the area of a segment of a circle.

Rule I.

Find the area of the sector having the same arch with the segment by the last problem. Find also the area contained by the chord of the segment and the two radii of the sector. Then take the sum of these two for the answer when the segment is greater than a semicircle, or take their difference when it is less than a semicircle. As is evident by inspection of the figure of a segment.

Fig. 23. *Example.* To find the area of the segment AEBDA, its chord AB being 12, and the radius AC or BC 10.

First, as AC : AD :: rad. : sin. $36^\circ\ 52'\frac{1}{7}=36.87$ degrees, the degrees in the angle ACE or arch AE. And their double, or $73.74 =$ the degrees in the whole arch AEB.

Now $.7854\times400=314.16$ the area of the whole circle.

Therefore $360^\circ : 73.74 :: 314.16 : 64.3504 =$ area of the sector CAEB.

Again $\sqrt{(CA^2-AD^2)} = \sqrt{(100-36)} = \sqrt{64} = 8 = DC$.

Therefore $AD\times DC = 6\times8 = 48 =$ area of the triangle.

Hence sector ACBA — triangle $ACB = 16.3504$ the area of seg. AEBDA.

Problem XIII.

To find the area of any segment of a parabola, that is the space included by any arch of a parabola, and the straight line joining its extremities.

Rule.

Multiple the base of the segment by its height, and take $\frac{2}{3}$ of the product for the area.

This rule is demonstrated in Prop. 12. Part I. Conic Sections.

Fig. 24. *Example.* The base AB of a parabolic segment ACB is 10, and its altitude CD, (that is, the greatest line that can be drawn in the segment perpendicular to the base AB) is 4: What is its area?

$$\text{Here } 10\times4\times\tfrac{2}{3}=\frac{80}{3}=26\tfrac{2}{3} \text{ the area.}$$

Problem XIV.

To find the area of an ellipse.

Rule.

Multiply the product of the two axes by the number .7854 for the area of the ellipse.

For the area of an ellipse is equal to the area of a circle whose diameter is a mean proportional between the axes of the ellipse, (Conic Sections, Part II. Prop. 22.) that is, to the area of a circle, the square of whose diameter is equal to the product of the axes. But by Prob. X. the area of a circle is equal to the square of the diameter multiplied by .7854; therefore the area of an ellipse is equal to the product of the axes multiplied by the same number .7854.

Example. If the axes of an ellipse, ABCD, be 35 and 25. What is the area? Fig. 25.

$$35\times25\times.7854=687.225 \text{ the area.}$$

Note. As to hyperbolic areas, the mathematical reader will find formulas for their exact mensuration in Fluxions, § 152. Ex. 4. and 5.

Problem XV.

To find nearly the area of a figure bounded by any curve line $A\,a\,a''\,a''$, &c. P, and a straight line BQ and AB, PQ two other straight lines drawn from the extremities of the curve perpendicular to BQ.

Rule.

Let BQ, the base of the figure, be divided into any even number of equal parts by the perpendiculars $b\,a$, $b'\,a'$, $b''\,a''$, &c. which meet the curve in the points a, a', a'', &c. Fig. 26.

Let F and L denote the first and last perpendiculars AB and PQ.

Let E denote the sum of all the remaining even perpendiculars, viz. $a\,b$, $a''\,b''$, $a''''\,b''''$, the second, fourth, sixth, &c.

Let R denote the sum of the remaining perpendiculars, viz. $a'\,b'$, $a'''\,b'''$, &c.

And put D for B b, or bb', &c. the common distance between the perpendiculars.

Then the area of the figure will be nearly equal to

$$\tfrac{1}{3}D\times(F+L+4\,E+2\,R);$$

and the approximation will be so much the more accurate according as the number of perpendiculars is the greater.

Demonstration. Join the tops of the first and third perpendiculars by the line A a' meeting the second perpendicular in E, and draw CD through a so as to form the parallelogram A a' DC; then the space bounded by the curve line A $a\,a'$ and the three straight lines AB, B b', $b'\,a'$ will be made up of the trapezoid AB $b'\,a'$, and the space bounded by the arch A $a\,a'$ and its chord A a'. Now if the arch A $a\,a'$ be small, this last space will be nearly two-thirds of the parallelogram AD, for it will be nearly equal to the area contained by the straight line A a', and an arch of a parabola passing through the points A, a, a', and having $a\,b$ for a diameter, which area is $\frac{2}{3}$ of its circumscribing parallelogram. (Conic Sections, Part I. Prop. 12). Therefore the space A $a\,a'\,b'$ BA will be nearly equal to the sum of the trapezoid AB $b'\,a'$ and $\frac{2}{3}$ of the parallelogram AD, which sum is evidently equal to $\frac{1}{3}$ of the trapezoid AB $b'\,a'$, together with $\frac{2}{3}$ of the trapezoid CB b' D.

CBb'D. Now the area of the trapezoid AB$b'a'$ is $\frac{AB+a'b'}{2}\times Bb'$ (Geometry, Sect. IV. Theor. 7.) $=\frac{AB+a'b'}{2}\times 2Bb$; and in like manner the area of the trapezoid CBb'D is $\frac{CB+Db'}{2}\times Bb'=ab\times 2Bb$; therefore the area of the figure A$aa'b'$B is nearly

$$\tfrac{1}{3}\times\frac{AB+a'b'}{2}\times 2Bb+\tfrac{2}{3}\times ab\times 2Bb$$

$$=\tfrac{1}{3}(AB+4ab+a'b')Bb.$$

In the very same way it may be shewn that the area of the figure $a'\,a''\,a'''\,b'''\,b'$ is nearly

$$\tfrac{1}{3}(a'b'+4a''b''+a'''b''')\times Bb,$$

and that the area of the figure $a'''\,a^{iv}$ PQb''' is nearly

$$\tfrac{1}{3}(a'''b'''+4a^{iv}b^{iv}+PQ)\times Bb.$$

Therefore, the area of the whole figure bounded by the curve line AP, and the straight lines AB, BQ, QP, is nearly equal to the sum of these three expressions, namely to

$$\tfrac{1}{3}Bb\times\left\{\begin{array}{c}AB+PQ\\+4(ab+a''b''+a^{iv}b^{iv})\\+2(a'b'+a'''b''')\end{array}\right\}$$

as was to be demonstrated.

Fig. 7. *Example* 1. Let it be required to find the area of the quadrant ABC, whereof the radius AC=1.

Let AC be bisected by the perpendicular DE, and let CD be divided into four equal parts by the perpendiculars mn, pq, rs. Now because CA=1, therefore CD=$\frac{1}{2}$, Cr=$\frac{1}{8}$, Cp=$\frac{1}{4}$, Cm=$\frac{3}{8}$. Hence DE=$\sqrt{(EC^2-CD^2)}=\sqrt{(1-\frac{1}{4})}=\frac{1}{2}\sqrt{3}$; and in like manner $rs=\frac{1}{8}\sqrt{55}$, $pq=\frac{1}{4}\sqrt{15}$, $mn=\frac{1}{8}\sqrt{63}$. Therefore

$F+L=1+\frac{1}{2}\sqrt{3}$ =	1.8660
$4E=\frac{1}{2}\sqrt{55}+\frac{1}{2}\sqrt{63}$ =	7.6767
$2R=\frac{1}{2}\sqrt{15}$ =	1.9365
The sum	11.4792
Multiply by $\frac{1}{3}$ D =	$\frac{1}{24}$
The product is	.4783
Subtract the triangle CDE =	.2165
There remains the sector CBE =	.2618
The triple of which is the quadrant ABC =	.7854

Fig. 8. *Ex.* 2. To find the area of the hyperbola FDM, of which the absciss FM=10, the semiordinate MD=12, and semitransverse CF=15.

Let FM be divided into five equal parts by the semiordinates HI, mn, pq, rs. Thus CH=17, Cm=19, Cp=21, Cr=23, CM=25. Now, since from the nature of the curve, $\sqrt{(CM^2-CF^2)}$: MD :: $\sqrt{CH^2-CF^2)}$: HI (Conic Sections, Part III. Prop. 19. and Geometry, Sect. IV. Theor. 12.), that is, in numbers, 20 : 12 :: 8 : HI, therefore HI=$\frac{24}{5}$. In like manner we find $mn=\frac{6}{5}\sqrt{34}$, $pq=\frac{18}{5}\sqrt{6}$, and $rs=\frac{12}{5}\sqrt{19}$. Therefore

F+L(=HI+MD) =	16.8
4E(=4mn+4rs) =	68.8399
2R(=2pq) =	17.6363
The figure HIDM =	103.2762 × $\frac{2}{3}$ = 68.8508

to which adding FIH, considered as a portion of a parabola, we have 75.245 for the area of the hyperbola.

Of LAND-SURVEYING.

The instruments most commonly employed in land-surveying are the Chain, the Plane Table, and Cross.

A statute acre of land being 160 square poles, the chain is made 4 poles, or 66 feet in length, that 10 square chains, (or 100,000 square links) may be equal to an acre. Hence each link is 7.92 inches in length.

The plane table is used for drawing a plan of a field, and taking such angles as are necessary to calculate its area. It is of a rectangular form, and is surrounded by a moveable frame, by means of which a sheet of paper may be fixed to its surface. It is furnished with an index by which a line may be drawn on the paper in the direction of any object in the field, and with scales of equal parts by which such lines may be made proportional to the distances of the objects from the plane table when measured by the chain, and its frame is divided into degrees for observing angles.

The cross consists of two pair of sights set at right angles to each other upon a staff having a pike at the bottom to stick into the ground. Its use is to determine the points where a perpendicular drawn from any object to a line will meet that line; and this is effected by finding by trials a point in the line, such that the cross being fixed over it so that one pair of the sights may be in the direction of the line, the object from which the perpendicular is to be drawn may be seen through the other pair; then the point thus found will be the bottom of the perpendicular, as is evident.

A theodolite may also be applied with great advantage to land-surveying, more especially when the ground to be measured is of great extent.

In addition to these, there are other instruments employed in surveying, as the perambulator, which is used for measuring roads and other great distances. Levels, with telescopic or other sights, which are used to determine how much one place is higher or lower than another. An ofsett-staff for measuring the ofsetts and other short distances. Ten small arrows, or rods of iron or wood, which are used to mark the end of every chain length. Pickets or staves with flags to be set up as marks or objects of direction; and lastly, scales, compasses, &c. for protracting and measuring the plan upon paper.

The observations and measurements are to be regularly entered as they are taken, in a book which is called the Field-book, and which serves as a register of all that is done or occurs in the course of the survey.

To

Of Plane Figures.

To Measure a Field by the Chain.

Fig. 29. Let $AmBCDq$ represent a field to be measured. Let it be resolved into the triangles AmB, ABD, BCD, AqD. Let all the sides of the large triangles ABD, BCD, and the perpendiculars of the small ones AmB, AqD from their vertices m, q be measured by the chain, and the areas calculated by the rules delivered in this section, and their amount is the area of the whole. But if, on account of the curvature of its sides the field cannot be wholly resolved into triangles, then, either a straight line may be drawn over the curve side, so that the parts cut off from the field, and those added to it, may be nearly equal; or, without going beyond the bounds of the field, the curvilineal spaces may be measured by the rule given in Prob. XV. of this section.

To Measure a Field with the Plane Table.

Fig. 30. Let the plane table be fixed at F, about the middle of the field ABCDE, and its distances FA, FB, FC, &c. from the several corners of the field measured by the chain. Let the index be directed from any point assumed on the paper to the points A, B, C, D, &c. successively, and the lines F a, F b, F c, drawn in these directions. Let the angles contained by these lines be observed, and the lines themselves made proportional to the distances measured. Then their extremities being joined, there will be formed a figure $a\ b\ c\ d\ e$ similar to that of the field; and the area of the field may be found by calculating the areas of the several triangles of which it consists.

To Plan a field from a given Base Line.

Fig. 31. Let two stations A, B be taken within the field, but not in the same straight line with any of its corners; and let their distance be measured. Then the plane table being fixed at A, and the point a assumed on its surface directly above A, let its index be directed to B, and the straight line $a\ b$ drawn along the side of it to represent AB. Also, let the index be directed from a to an object at the corner C, and an indefinite straight line drawn in that direction, and so of every other corner successively. Next, let the plane table be set at B, so that b may be directly over B, and $b\ a$ in the same direction with BA, and let a straight line be drawn from b in the direction BC. The intersection of this line with the former, it is evident will determine the point C, and the triangle $a\ b\ c$ on the paper will be similar to ABC in the field. In this manner all the other points are to be determined, and these being joined there will be an exact representation of the field.

If the angles at both stations were observed, as the distance between them is given, the area of the field might be calculated from these data, but the operation is too tedious for practice. It is usual therefore to measure such lines in the figure that has been constructed as will render the calculation easy.

SECTION III.

MENSURATION OF SOLIDS.

Problem I.

To find the surface of a right prism, or cylinder.

Of Solids.

Rule.

Multiply the perimeter of the end by the length or height of the solid, and the product will be the surface of all its sides; to which add also the area of the two ends of the prism when required.

The truth of this rule will be evident, if it be considered that the sides of a right prism are rectangles, whose common length is the same as the length of the solid, and their breadths taken altogether make up the perimeter of the ends of the prism. And as a cylinder may be considered as the limit of all the prisms which can be inscribed in or circumscribed about its base so the surface of the cylinder will be the limit of the surfaces of these prisms, and the expression for that limit is evidently the product of the circular base by its height. Or a cylinder may be considered as a prism of an indefinitely great number of sides.

Ex. 1. What is the surface of a cube, the length of its side AB being 20 feet? Fig. 3[illegible]

Here $4\times 20=$ 80 the perim. of end.

And $80\times 20=$ 1600 the four sides.
And $2\times 20\times 20=$ 800 the top and bottom.

The sum 2400 = the area or surface.

Ex. 2. What is the convex surface of a cylinder whose length AB is 20 feet, and the circumference of its base 3 feet? Fig. 33

Here $3\times 20=60$ feet, the answer.

Problem II.

To find the surface of a right pyramid or cone.

Rule.

Multiply the perimeter of the base by the slant height or length of the side, and half the product will evidently be the surface of the sides, or the sum of the areas of all the triangles which form it. To which add the area of the end or base, if required.

Note. Here a cone is considered as a pyramid of an indefinitely great number of sides.

Ex. 1. What is the upright surface of a triangular pyramid, ABCD, the slant height, AE, being 20 feet, and each side of the base 3 feet? Fig. 3[illegible]

$$\text{Here } \frac{3\times 3\times 20}{2}=90 \text{ feet, the surface.}$$

Ex. 2. Required the convex surface of a cone, the slant height AB being 50 feet, and the diameter of its base $8\frac{1}{2}$ feet. Fig. 3[illegible]

Here $8.5\times 3.1416=$ circum. of base.

$$\text{And } \frac{8.5\times 3.1416\times 50}{2}=667.59, \text{ the answer.}$$

Problem

Of Solids.

PROBLEM III.

To find the surface of the frustum of a right pyramid or cone, being the lower part, when the top is cut off by a plane parallel to the base.

RULE.

Add together the perimeters of the two ends, and multiply their sum by the slant height, and take half the product for the answer.

The truth of this rule will be evident if it be considered that the sides of the frustum are trapezoids, whose parallel sides bound its top and base, and whose common breadth is its slant height.

Fig. 6. *Example.* How many square feet are in the surface of a frustum AG of a square pyramid, whose slant height RE is 10 feet; also each side of the greater end AC is 3 feet 4 inches, and each side of the lesser end EG 2 feet 2 inches?

Here $3\frac{1}{3}\times 4=13\frac{1}{3}$ the per. of gr. end.

And $2\frac{1}{6}\times 4=8\frac{2}{3}$ the per. of less end.

And their sum is 22 feet.

Therefore $\frac{22\times 10}{2}=110$ feet, is the answer.

PROBLEM IV.

To find the solid content of any prism or cylinder.

RULE.

Find the area of the base or end of the figure, and multiply it by the height or length, and the product will be the area.

This rule follows immediately from Theor. 11. Sect. VIII. and Theor. 2. Sect. IX. GEOMETRY.

Ex. 1. What is the solid content of a cube AG, the length of whose sides is 24 inches?

Here $24\times 24=576$ sq. inches, the area of the end.

And $576\times 24=13824$ cub. inches is the solidity.

Ex. 2. Required the content of a triangular prism, whose length AD is 20 feet, and the sides of its triangular base ABC are 3, 4, and 5 feet.

First, the area of the triangular base is found by Rule 3. of Prob. 3. Sect. II. to be

$\sqrt{(6\times 3\times 2\times 1)}=6$ sq. feet.

Therefore $6\times 20=120$ cub. feet the solidity.

Ex. 3. The Winchester bushel is a cylinder $18\frac{1}{2}$ inches in diameter, and eight inches deep. How many cubic inches does it contain?

By Prop. 10. of Sect. II. the area of its base is

$$.7854\times 18.5^2=268.803 \text{ sq. inches};$$

Therefore $268.803\times 8=2150.424$ is the solid content.

PROBLEM V.

To find the solid content of any pyramid or cone.

RULE.

Find the area of the base, and multiply that area by the height, and one-third of the product will be the content of the solid.

This rule is demonstrated in Theor. 16. Sect. VIII. and Theor. 3. Sect. IX. GEOMETRY.

Ex. 1. What is the content of a triangular pyramid ABCD, whose perpendicular height AF is 30 feet, and each side of its base BCD is three feet. Fig. 34.

First, the area of the base, as found by Rule 3. of Prob. 3. Sect. II. is

$$\sqrt{(4.5\times 1.5\times 1.5\times 1.5)}=3.89711.$$

Therefore $\frac{3.89711\times 30}{3}=38.9711$ cub. feet is the solid content.

Ex. 2. What is the solid content of a cone, the radius BC of its base being nine inches, and its height AC 15 feet? Fig. 35.

Here $.7854\times\frac{3^2}{2^2}=1.76715$ is the area of the base in square feet.

And $\frac{1.76715\times 15}{3}=8.8357$ cub. feet is the solid content.

PROBLEM VI.

To find the solidity of the frustum of a cone or pyramid.

RULE.

Add into one sum the areas of the two ends, and the mean proportional between them, that is, the square root of their product, and one-third of that sum will be a mean area, which being multiplied by the perpendicular height or length of the frustum will give the content.

Demonstration. Let PABCD be any pyramid, and AG a frustum of it contained between ABCD its base, and EFGH, a plane parallel to the base. Put a for the side of a square equal to AC the base of the frustum; b for the side of a square equal to EG its top; h for LM the height of the frustum, and c for PL the height of the part of the pyramid above the frustum. Then a^2 is the area of the base of the frustum; b^2 is the area of its top; $\frac{1}{3}a^2(h+c)$ is the solid content of the whole pyramid; (GEOM. Sect. VIII. Theor. 16.) $\frac{1}{3}b^2c$ is the content of its upper part; and therefore Fig. 36.

$$\tfrac{1}{3}\left\{a^2(h+c)-b^2c\right\}$$

is the solid content of the frustum itself. Now the base and top of the frustum being similar figures, (Sect. VIII. Theor.

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Theor. 13.) their areas are to one another as the squares of AB and EF their homologous sides, (Sect. IV Theor. 27.). But AB : EF :: BP : PF (Sect. VII. Theor. 7. and Sect. IV. Theor. 20.) :: PM : PL, (Sect. VII. Theor. 14.) ; therefore the area of the base of the frustum is to the area of its top as $PM^2 : PL^2$, that is, $a^2 : b^2 :: (h+c)^2 : c^2$, and consequently $a : b :: h+c : c$; hence $a\,c=b\,h+b\,c$, and $c=\frac{b\,h}{a-b}$, and $h+c=\frac{a\,h}{a-b}$. Let these values of c and $h+c$ be now substituted in the preceding expression for the content of the frustum, and it will become, by proper reduction,

$$\tfrac{1}{3}\,h\frac{a^3-b^3}{a-b}.$$

Let the numerator of the fractional part of this formula be actually divided by its denominator, and we shall obtain for the area of the frustum this more simple expression,

$$\tfrac{1}{3}\,h\,(a^2+a\,b+b^2),$$

which formula, when expressed in words, is the rule. And as a cone may be considered as the limit of all the pyramids that can be inscribed in it, when the number of sides is conceived indefinitely increased, it is evident that the rule will apply alike to the cone and pyramid.

Ex. 1. Required the solidity of the frustum of a hexagonal pyramid, the side of whose greater end is four feet, and that of its lesser end is three feet, and its height nine feet.

First, by Prob. 7. Sect. II. the area of the base of the frustum is found to be 41.569, and the area of its lesser end 23.383 square feet. And the mean proportional between these is

$$\sqrt{(41.569\times 23.383)}=31.177.$$

Hence the mean area is

$$\tfrac{1}{3}\,(23.383+41.569+31.177)=32.043.$$

And the solid content of the frustum is

$$32.043\times 9=288.387 \text{ cubic feet.}$$

Ex. 2. What is the solidity of the frustum of a cone, the diameter of the greater end being five feet, that of the lesser end three feet, and the altitude nine feet?

Here the area of the greater end is (by Prob. 10. Sect. II.) $5^2\times.7854$, and the area of the lesser end is $3^2\times.7854$, and the mean proportional between them is $\sqrt{(5^2\times 3^2\times .7854^2)}=5\times 3\times .7854$; therefore the mean area is

$$\frac{.7854}{3}\times(5^2+3^2+5\times 3)=12.8282.$$

And the content of the frustum

$$12.8282\times 9=115.4538 \text{ cub. feet.}$$

Problem VII.

To find the surface of a sphere, or of any segment or zone of it.

Rule.

Multiply the circumference of the sphere by the height of the part required, and the product will be the curve surface, whether it be a segment, a zone, or the whole sphere.

Note. The height of the whole sphere is its diameter.

The truth of this rule has been already shown in the article Fluxions, § 165. It may however be deduced from principles more elementary, by reasoning as follows. Let PCQ be a semicircle, and ABCDE several successive sides of a regular polygon inscribed in it. Fig. 37.
Conceive the semicircle to revolve about the diameter PQ as an axis, then the arch ABCDE will generate a portion of the surface of a sphere, and the chords AB, BC, CD, &c. will generate the surfaces of frustums of cones; and it is easy to see that the number of chords may be so great that the surface which they generate shall differ from the surface generated by the arch ACE by a quantity which is less than any assigned quantity. Bisect AB in L, and draw AF, LM, BG, CH, &c. perpendicular to PQ. For the sake of brevity, let *circ.* AF denote the circumference of a circle whose radius is AF. Then because AF, BG, LM, are to each other respectively as *circ.* AF, *circ.* BG, *circ.* LM (Geom. Sect. VI. Prop. 4.), and because $\frac{1}{2}$ (AF + BG) = LM, therefore $\frac{1}{2}$ (*circ.* AF + *circ.* BG) = *circ.* LM. Now the area of the surface generated by the chord AB is $\frac{1}{2}$ (*circ.* AF + *circ.* BG) × AB, Prob. 3.) therefore the same area is also equal to (*circ.* LM) × AB. Draw AO parallel to FG, and draw LN to the centre of the circle. Then the triangles AOB, LMN are manifestly similar; therefore AB : AO :: NL : LM :: *circ.* NL : *circ.* LM; and hence AO × *circ.* NL = AB × *circ.* LM. But this last quantity has been proved equal to the surface generated by AB, therefore the same surface is equal to AO × *circ.* NL, or to FG × *circ.* NL, that is, to the rectangle contained by FG and the circumference of a circle inscribed in the polygon. In the same way it may be shown that the surfaces generated by BC, CD, DE, are respectively equal to GH × *circ.* LN, HI × *circ.* LN, IK × *circ.* LN. Therefore the whole surface generated by the chords AB, BC, CD, DE, &c. is equal to (FG + GH + HI + IK) × *circ.* LN = FK × *circ.* LN. Conceive now the number of chords between A and E to be indefinitely increased; then, observing that the limit of the surface generated by the chords is the surface generated by the arch ABCDE, and that the limit of NL is NP, the radius of the generating circle, it follows that the spherical surface or zone generated by the arch ACE is equal to the product of the zone.

Ex. 1. What is the superficies of a globe whose diameter is 17 inches?

First $17\times 3.1416=53.4072$ inches = the circum.

Then $53.4072\times 17=907.9224$ sq. inches = 6.305 square feet, the answer.

Ex. 2. What is the convex surface of a segment 8 inches in height cut off from the same globe?

Here

Of Solids. Here $53.4072 \times 8 = 427.2576$ sq. inches $= 2.967$ sq. feet, the answer.

PROBLEM VIII.

To find the solidity of a sphere.

RULE I.

Multiply the area of a great circle of the sphere by its diameter, and take $\frac{2}{3}$ of the product for the content.

RULE II.

Multiply the cube of the diameter by the decimal .5236 for the content.

The first of these rules is demonstrated in GEOMETRY, Sect. IX. Theor. 6. And the second is deduced from the first, thus: put d for the diameter of the sphere, then $d^2 \times .7854$ is the area of a great circle of the sphere, and by the first rule $\frac{2}{3} d \times d^2 \times .7854 = d^3 \times .5236$ is its content.

Example. What is the content of a sphere whose diameter is 6 feet?

Answer $6^3 \times .5236 = 113.0976$ cub. feet.

PROBLEM IX.

To find the solid content of a spherical segment.

RULE.

From 3 times the diameter of the sphere take double the height of the segment, then multiply the remainder by the square of the height, and the product by the decimal .5236 for the content.

This rule has been investigated in FLUXIONS, § 163. But it may be proved in a more elementary manner by means of the following axiom. *If two solids be contained between two parallel planes; and if the sections of these solids by a third plane parallel to the other two, at any altitude, be always equal to one another, then the solids themselves are equal. Or more generally thus. If two solids between two parallel planes be such, that any sections of them by a third plane parallel to the other two have always to each other the same given ratio, then the solids themselves are to one another in that ratio.* We have given this proposition in the form of an axiom for the sake of brevity, but its truth may be strictly demonstrated, as has been done when treating of pyramids and the sphere, in GEOMETRY, Sect. 8. and 9.

Fig. 38. Let us now suppose ABE to be a quadrant; C the centre of the circle; AFEC a square described about the quadrant; and CF the diagonal of the square. Suppose the figures to revolve about AC as an axis, then the quadrant will generate a hemisphere, the triangle ACF will generate a cone, and the square AE a cylinder. Let these three solids be cut by a plane perpendicular to the axis, and meeting the plane of the square, in the line DHBG; and join CB. Then because CDB is a right-angled triangle, a circle described with CB as a radius is equal to two circles described with CD and DB as radii (GEOMETRY, Sect. VI. Prop. 4. Cor. 2.). But CB=DG, and since CA=AF, therefore CD=DH; therefore the circle described with the radius DG, is equal to the sum of the circles described with the radii DH, DB; that is, the section of the cylinder at any altitude, is equal to the corresponding sections of the sphere and cone taken together. Consequently, by the foregoing axiom, the cylinder is equal to the hemisphere and cone taken together, and also the segment of the cylinder between the planes AF, DG is equal to the sum of the segments of the hemisphere and cone contained between the same planes. Put 2 CE, or 2 AF, the diameter of the circle, $=d$, and AD, the height of the spherical segment, $=h$. Then $AC = \frac{1}{2} d$ and $2CA - 2AD = 2CD = d - 2h$. Let n denote the number .7854. Then the area of the base common to the conic frustum AH, and cylinder AG, is $n d^2$, (Sect. II. Prob. 10.), and the area of the top of the frustum is $n(d-2h)^2$, and the mean proportional between these areas is $n(d-2h)d$. Therefore the solid content of the frustum is (by Prob. 6. of this sect.)

$$\frac{1}{3}\left\{ n d^2 + n(d-2h)^2 + n d(d-2h) \right\} \times h.$$

$$= n d^2 h - 2 n d h^2 + \frac{4}{3} n h^3.$$

Now the solid content of the cylinder is $n d^2 h$: (Prob. 1.). Therefore the solid content of the spherical segment, (which is equal to the difference between the cylinder AG and conic frustum AH) is equal to

$$n d^2 h - (n d^2 h - 2 n d h^2 + \tfrac{4}{3} n h^3),$$

that is, to $2 n d h^2 - \frac{4}{3} n h^3$, or to

$$\frac{2n}{3}(3d - 2h)h^2,$$

which expression, if it be considered that $\frac{2n}{3}$ or $\frac{2 \times .7854}{3}$ is equal to .5236, is evidently the same as that given by the rule.

Example. In a sphere whose diameter is 21, what is the solidity of a segment whose height is 4.5 inches?

First $3 \times 21 - 2 \times 4.5 = 54$.

Then $54 \times 4.5 \times 4.5 \times .5236 = 572.5566$ inches, the solidity required.

PROBLEM X.

To find the solid content of a paraboloid, or solid, produced by the rotation of a parabola about its axis.

RULE.

Multiply the area of the base by the height, and take half the product for the content.

To demonstrate this rule, let AGC and BHD be two equal semi-parabolas lying in contrary directions, and having their vertices at the extremity of the line AB. Fig. 39. Let AD, BC be ordinates to the curves. Complete the rectangle ABCD, and conceive it to revolve about AB as an axis; then the rectangle will generate a cylinder, the radius of whose base will be AD, and the two semi-parabolas will generate two equal paraboloids having the same base and altitude as the cylinder. Let a plane be drawn perpendicular to the axis, and let FHGE be the common section of this plane and the generating

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generating figure. Let P denote the parameter of the axis. Then since

$$EG^2 = P \times AE,$$
$$\text{and } EH^2 = P \times EB,$$
$$EG^2 + EH^2 = P \times AB = CB^2.$$

Hence it appears, as in the demonstration of the preceding rule, that of the solids described by ADCB, ACB, ADB between the same parallel planes, the section of the cylinder at any altitude is equal to the corresponding sections of the paraboloids taken together. Consequently (by the Axiom) the cylinder is equal to both the paraboloids taken together; hence each is half a cylinder of the same base and altitude agreeing with the rule.

The same thing is also proved in FLUXIONS, § 163.

Example. If the diameter of the base of a paraboloid be 10 and its height 12 feet; what is its content?

Here $10 \times .7854 = 7.854$ the area of the base.

And $\frac{1}{2} \times 7.854 \times 12 = 47.124$ cub. feet is the solidity.

PROBLEM X.

To find the solid content of a frustum of a paraboloid.

RULE.

Add together the areas of the circular ends, then multiply that sum by the height of the frustum, and take half the product for its solid content.

To prove this rule put A and a for the greater and lesser ends of the frustum, and h for its height; also let c denote the height of the portion cut off from the complete paraboloid, so as to form the frustum. Then, by the last problem, the content of the complete paraboloid is $\frac{1}{2} A\,(h+c)$, and the content of the part cut off is $\frac{1}{2}\,a\,c$, therefore the content of the frustum is

$$\tfrac{1}{2}\left\{A(h+c) - a\,c\right\} = \tfrac{1}{2}\left\{A\,h + c(A-a)\right\}$$

But from the nature of the parabola, $c : h+c :: a : A$; hence $A\,c = a\,h + a\,c$ and $c = \frac{a\,h}{A-a}$.

Let this value of c be substituted instead of it in the above expression for the content of the frustum, and it becomes

$$\tfrac{1}{2}(A\,h + a\,h) = \tfrac{1}{2}h(A+a),$$

and hence is derived the rule.

Example. Required the solidity of the frustum of a paraboloid, the diameter of the greater end being 58, and that of the lesser end 30, and the height 18.

First, (by Prob. 10. Sect. II.) we find the areas of the ends to be $58^2 \times .7854$, and $30^2 \times .7854$; therefore their sum is $(58^2 + 30^2) \times .7854 = 4264 \times .7854$. And the content of the figure is $\frac{1}{2} \times 4264 \times .7854 \times 18 = 30140.5104$, the answer.

PROBLEM XI.

To find the solid content of a parabolic spindle or solid generated by the rotation of AEB an arc of a parabola, about AB an ordinate to the axis. Fig. 40.

RULE.

Multiply the area of the middle section by the length, and take $\frac{8}{15}$ of the product for the content of the solid.

For the investigation of this rule we must refer the reader to FLUXIONS, § 163. *Ex.* 2.

Example. The length of the parabolic spindle AEB e A is 60, and the middle diameter E e 34; what is the solidity?

Here $34^2 \times .7854$ is area of the middle section.

Therefore $34^2 \times .7854 \times 60 \times \frac{8}{15} = 29053.5168$ is the solidity required.

PROBLEM XII.

To find the solid content of the frustum of a parabolic spindle, one of the ends of the frustum passing through the centre of the spindle.

RULE.

Add into one sum eight times the square of the diameter of the greater end, and three times the square of the lesser end, and four times the product of the diameters; multiply the sum by the length, and the product multiplied by .05236, or $\frac{1}{15}$ of .7854, will be the content.

For, referring the reader to FLUXIONS, § 163. Ex. 2. as before, and substituting h for $AC = \frac{1}{2}b$, but, in other respects, retaining the figure and notation, we have this general expression for the segment APp,

$$\frac{\pi x^3}{a^2}\left(\frac{4h^2}{3} - hx + \frac{x^2}{5}\right),$$

which, when $x = h$ gives $\frac{8\pi h^5}{15a^2}$ for the value of the semi-spindle. From this quantity let the former be subtracted, and there will remain

$$\frac{8\pi h^5}{15a^2} - \frac{\pi x^3}{a^2}\left(\frac{4h^2}{3} - hx + \frac{x^2}{5}\right)$$

for the content of the frustum. In this expression let z be put instead of $h-x$ or CD, and, denoting CE the radius of the greater end of the spindle by d, let $\frac{h^2}{d}$ be substituted instead of its value a. Then we shall have the content of the frustum otherwise expressed by

$$\frac{\pi d^2 z}{h^2}\left\{h^4 - \frac{2h^2z^4}{3} + \frac{z^4}{5}\right\}$$

which value, by putting $h\sqrt{\frac{d-y}{d}}$ in its two last terms

instead

Of Solids. instead of z, is changed to

$$\pi z \times \frac{8d^2+4dy+3y^2}{15},$$

and hence is derived the preceding rule.

Example. Suppose the diameter of the greater end to be 8, and the diameter of the lesser end 6, and the length 10, required the content?

First $8\times 8^2+3\times 6^2+4\times 8\times 6=812$.

Then, $812\times 10\times .05236=425.1632$, the content.

Problem XIII.

To find the solid content of a spheroid, or solid generated by the rotation of an ellipse about either axis.

Rule.

Multiply continually together the fixed axis, and the square of the revolving axis, and the number .5236 or $\frac{1}{6}$ of 3.1416, and the last product will be the solidity.

Fig. 41. For, let the semiellipse ADB, and semicircle AEB, revolve about the same fixed axis AB, and thus generate a spheroid and sphere. Let CD the revolving semiaxis of the ellipse meet the circle in E, and draw QP any ordinate to the fixed axis meeting the circle in R. Then, from the nature of the ellipse $PQ^2 : PR^2 :: CD^2 : CE^2$ or CA^2 (Conic Sections, Part II. Prop. 11. Cor. 3.). Hence it follows, (Geometry, Sect. VI. Prop. 4.), that every section of the spheroid is to the corresponding section of the sphere in the same given ratio, namely, that of the square of the revolving axis to the square of the fixed axis; therefore (Axiom in the dem. of Prob. 9.) the whole spheroid is to the whole sphere in the same ratio. That is, (because the content of the sphere is $AB^3\times .5236$) $AB^2 : (2CD)^2 :: AB^3\times .5236$: (the cont. of spheroid). Hence the content of the spheroid is $AB\times(2CD)^2\times .5236$.

Ex. 1. What is the solid content of an oblong spheroid, or solid generated by the rotation of an ellipse about its greater axis, the axes being 50, and 30?

Here $50\times 30^2\times .5236=23562$, the content.

Ex. What is the solid content of an oblate spheroid, or solid generated by the rotation of an ellipse about its lesser axis, the two axes being as before?

Here $30\times 50^2\times .5236=39270$ the answer.

Problem XIV.

To find the solid content of the frustum of a spheroid, its ends being perpendicular to the fixed axis, and one of them passing through the centre.

Rule.

To the area of the less end add twice that of the greater, multiply the sum by the altitude of the frustum, and $\frac{1}{3}$ of the product will be the content.

Note. This rule will also apply to the sphere.

Demonstration. Let ABE be a quadrant of an ellipse, C its centre, CAFE its circumscribed rectangle, and CF its diagonal. Draw any straight line DG parallel to GE, meeting AC, CF, ABE and EF in D, H, B, and G. Then by Conic Sections, Part II. Prop. 11. Fig. 42.

$$CE^2 \text{ or } AF^2 : DB^2 :: CA^2 : CA^2-CD^2,$$

and by sim. tr. $AF^2 : DH^2 :: CA^2 : CD^2$.

Therefore (Geometry, Sect. III. Theor. 8.),

$$AF^2 : DB^2+DH^2 :: CA^2 : CA^2;$$

$$\text{Hence } DB^2+DH^2=AF^2=DG^2.$$

Conceive now the figure to revolve about AC as an axis, so that the elliptic quadrant may generate the half of a spheroid, the rectangle AE a cylinder, and the triangle ACF a cone; then it is evident (as was shown in the case of the sphere in Prob. 9.) that every section of the first of these solids by a plane perpendicular to the axis is equal to the difference of the sections of the other two, and consequently that the frustum of the spheroid between CE and DG is equal to the difference between the cylinder having DG or CE for the radius of its base, and CD for its altitude, and the cone having DH for the radius of its base, and DC for its altitude.

Put n for the number 3.1416, then (Prob. 4.) the content of the cylinder is $4n\times DG^2\times CD$, and (Prob. 5.) the content of the cone is $\frac{4}{3}n\times DH^2\times CD$, and therefore the content of the frustum of the spheroid is

$$4n\times CD\,(DG^2-\tfrac{1}{3}DH^2).$$

But it was shewn that $DH^2=DG^2-DB^2$; therefore the content of the frustum is also equal to

$$\tfrac{4}{3}n\times CD\,(2CE^2+DB^2),$$

and hence is derived the rule.

Ex. Suppose the greater end of the frustum to be 15, the less end 9, and the length 10 inches, required the content?

The area of the greater end is $15^2\times .7854$, and the area of the less $9^2\times .7854$, therefore the content is

$$.7854\,(9^2+2\times 15^2)\times \tfrac{10}{3}=1390.158 \text{ cubic inches.}$$

Problem XV.

To find the solid content of a hyperboloid, or solid generated by the rotation of a hyperbola about its transverse axis.

Rule.

As the sum of the transverse axis and the height of the solid is to the sum of the said transverse axis and $\frac{2}{3}$ of the height, so is half the cylinder of the same base and altitude to the solidity of the hyperboloid.

Demonstration. Let BAb be a hyperbola, Aa its transverse axis, C its centre, CF, Cf its asymptotes, FAf a tangent at its vertex. Draw FE parallel to CA, and draw any straight line parallel to Ff, meeting the asymptotes in H and h, the curve in B and b, the axis in D, and the line FE in G. Then, because $AF^2=BH\times hB$ (Conic Sections, Part III. Prop. 11.) and Fig. 43.

Of Solids.

and $HB \times hB = DH^2 - DB^2$ (GEOMETRY, Sect. IV. Theor. 12.), therefore $AF^2 = DH^2 - DB^2$, and $DB^2 = HD^2 - DG^2$. Hence it appears, that if the figure be conceived to revolve about CA as an axis, so that the hyperbolic arc AB may generate a hyperboloid, the triangle DCH a cone, and the rectangle DAFG a cylinder, any section of the first of these solids by a plane H h, perpendicular to the axis, will be equal to the difference of the sections of the other two by the same plane. Therefore the hyperboloid BA b is equal to the difference between the conic frustum FH hf and the cylinder FG gf. Let A a the transverse axis be denoted by p, Ff= its conjugate axis by q, AD the height of the solid by h, B b its base by b. Then, because by similar triangles, &c.

$$CA : CD :: Ff : Hh :: Ff^2 : Ff \times Hh,$$

therefore $Ff \times Hh = \frac{CD}{CA} \times Ff^2 = \frac{(\frac{1}{2}p + h)\, q^2}{\frac{1}{2}p} = q^2 + \frac{2hq^2}{p}$.

Now $Ff^2 = q^2$, and $Hh^2\ (= Bb^2 + Ff^2) = b^2 + q^2$, therefore putting n for .7854, we have (by Prob. 6.) the content of the conic frustum FH hf equal to.

$$\frac{nh}{3}\left(q^2 + b^2 + q^2 + q^2 + \frac{2hq^2}{p}\right) = \frac{nh}{3}\left(3q^2 + b^2 + \frac{2hq^2}{p}\right);$$

from this subtract nhq^2, the expression for the content of the cylinder FG gf, and there will remain

$$\frac{nh}{3}\left(b^2 + \frac{2hq^2}{p}\right)$$

for the content of the hyperboloid. But from the nature of the hyperbola

$$Aa^2 : Ff^2 :: AD \times Da : BD^2,$$

that is, $p^2 : q^2 :: (p+h)\,h : \frac{1}{4}b^2$;

therefore $\frac{2hq^2}{p} = \frac{p\,b^2}{2\,(p+h)}$; and hence the content of the hyperboloid is also equal to

$$\frac{nh}{3}\left(b^2 + \frac{p\,b^2}{2(p+h)}\right) = \frac{nhb^2}{2} \times \frac{p + \frac{2}{3}h}{p+h}.$$

Now if it be considered that the quantity nhb^2 is the expression for the content of a cylinder whose base is b and height h, it will appear evident, that this last formula is the same as would result from the foregoing rule.

Ex. Suppose the height of the hyperboloid to be 10, the radius of its base 12, and its transverse axis 30. What is its content?

1. Because a cylinder of the same base and altitude is $24^2 \times .7854 \times 10$, therefore, we have the proportion,

$$40 : \frac{110}{3} :: \frac{24^2 \times .7854 \times 10}{2} :$$

$$\frac{24^2 \times .7854 \times 10 \times 110}{40 \times 3 \times 2} = 2073.456,$$ the content of the solid as required.

OF GAUGING.

GAUGING treats of the measuring of casks, and other things falling under the cognizance of the officers of the excise, and it has received its name from a gauge or rod used by the practitioners of the art.

Of Gauging.

From the way in which casks are constructed, they are evidently solids of no determinate geometrical figure. It is, however, usual to consider them as having one or other of the four following forms:

1. The middle frustum of a spheroid.
2. The middle frustum of a parabolic spindle.
3. The two equal frustums of a paraboloid.
4. The two equal frustums of a cone.

We have already given rules by which the content of each of these solids may be found in cubic feet, inches, &c. But as it is usual to express the contents of casks in gallons, we shall give the rules again in a form suited to that mode of estimating capacity. Observing that in each case the lineal dimensions of the cask are supposed to be taken in inches.

PROBLEM I.

To find the content of a cask of the first, or spheroidal variety.

RULE.

To the square of the head diameter add double the square of the bung diameter, and multiply the sum by the length of the cask. Then let the product be multiplied by $.0009\frac{1}{4}$, or divided by 1077 for ale gallons, or multiplied by $.0011\frac{1}{3}$ or divided by 882 for wine gallons.

The truth of this rule may be proved thus. Put B for FG, the bung diameter, H for AH the head diameter, and L for AD, the length of the cask, then (by Prob. 14.) the content of the cask is $(2B^2 + H^2)\,L \times \frac{.7854}{3}$, which being divided by 282 (the cubic inches in an ale gallon) gives $(2B^2 + H^2)\,L \times .000928371$, or $(2B^2 + H^2) \times \frac{1}{1077.157} \times L$, for the content in ale gallons. And being divided by 231, (the cubic inches in a wine gallon) gives $(2B^2 + H^2) \times .00113333\,L$, or $(2B^2 + H^2) \times \frac{1}{882.355} \times L$. for the content in wine gallons. Fig. 44.

Ex. Suppose the bung and head diameters to be 32 and 24, and the length 40 inches. Required the content?

Here $(2 \times 32^2 + 24^2) \times 40 \times .0009\frac{1}{4} = 97.44$ ale gallons, is the content required.

And $(2 \times 32^2 + 24^2) \times 40 \times .0011\frac{1}{3} = 118.95$ wine gallons is the same content.

PROBLEM II.

To find the content of a cask of the second, or parabolic spindle form.

RULE.

To the square of the head diameter add double that of the bung diameter, and from the sum take $\frac{2}{5}$, or $\frac{4}{10}$ of

Of Gauging. of the square of the difference of the said diameters. Then multiply the remainder by the length, and the product multiplied, or divided by the same numbers as in the rule to last problem, will give the content.

For by Problem 12, the content in inches is

$$\frac{8\,B^2+4BH+3H^2}{15} \times .7854\,L;$$

and this formula may be otherwise expressed thus,

$$\left\{2\,B^2+H^2-\tfrac{2}{5}\,(B-H)^2\right\} \times \frac{.7854}{3} \times L,$$

and hence is derived the rule, the multipliers or divisors being evidently the same as in last problem.

Ex. The dimensions of a cask being the same as in last problem; required the contents?

Answer, $(2 \times 32^2 + 24^2 - \frac{2}{5} \times 8^2) \times 40 \times .0009\frac{1}{4} = 96.49$ the content in ale gallons.

And $10393.6 \times .0011\frac{1}{3} = 117.79$ the content in wine gallons.

Problem III.

To find the content of a cask of the third or paraboloidal variety.

Rule.

To the square of the bung diameter add the square of the head diameter, and multiply the sum by the length; then, if the product be multiplied by .0014, or divided by 718, the result will be the content in ale gallons; or if it be multiplied by .0017, or divided by 588, the result will be the content in wine gallons.

For by Problem 10. the content in inches is $\frac{1}{2}(B^2 + H^2) \times .7854\,L$; and this expression being divided by 282 gives $(B^2+H^2) \times .00139255\,L$ or $(B^2+H^2) \times \frac{1}{718.105} \times L$ for the content in ale gallons; and divided by 231 gives $(B^2+H^2) \times .0017\,L$ or $(B^2 \times H^2) \times \frac{1}{588.233}$ for the content in wine gallons.

Ex. Suppose the dimensions of a cask, as before; required the content?

Answer, $(32^2+24^2) \times 40 \times .0014 = 89.1$ the content in ale gallons.

And $64000 \times .0017 = 108.8$ the content in wine gallons.

Problem IV.

To find the content of a cask of the fourth or conical variety.

Rule.

To three times the square of the sum of the diameters add the square of the difference of the diameters; multiply the sum by the length; and multiply the result by $.00023\frac{1}{5}$, or divide it by 4308, for the content in ale gallons; or multiply the result by $.0028\frac{1}{3}$, or divide it by 3529, for the content in wine gallons.

For by Problem 6. the content in inches is $\frac{1}{3}(B^2 + BH + H^2) \times .7854\,L$, which expression is equivalent to

$$\left\{3(B+H)^2+(B-H)^2\right\} \times \frac{.7854}{12}\,L.$$

Now $\frac{.7854}{12}$ divided by 282 gives $.00023209 = \frac{1}{4308.628}$ the multiplier for ale gallons, and divided by 231 gives $.00028333 = \frac{1}{3529.42}$ the multiplier for wine gallons.

Ex. Supposing the dimensions of a cask as before, What is its contents?

Answer, $(3 \times 56^2 + 8^2) \times 40 \times .00023\frac{1}{5} = 87.93$ the content in ale gallons.

And $378880 \times .00028\frac{1}{3} = 107.35$, is the content in wine gallons.

As these four forms of casks are merely hypothetical, it may reasonably be expected that some degree of uncertainty will attend the application of the rules to actual measurement. The following rule, however, given by Dr Hutton in his excellent treatise on mensuration will apply equally to any cask whatever. And as the ingenious author observes, that its truth has been proved by several casks which have been actually filled with a true gallon-measure after their contents were computed by it, we presume that it is more to be depended upon in practice than the others.

Rule.

Add into one sum 39 times the square of the bung diameter, 25 times the square of the head diameter, and 26 times the product of the diameters; multiply the sum by the length, and the product by .00034; then the last product divided by 9 will give the wine gallons, and divided by 11 will give the ale gallons.

In investigating this rule the ingenious author assumed as a hypothesis, that one-third of a cask at each end is nearly the frustum of a cone, and that the middle part may be taken as the middle frustum of a parabolic spindle. This being supposed, let AB and CD be the two right-lined parts, and BC the parabolic part; produce AB and DC to meet in E, and draw lines as in the figure. Let L, B, and H denote the same as before. Then, since AB has the same direction as EB at B, ABE will be a tangent to a parabola BF, and therefore $FI = \frac{1}{2}EI$. But $BI = \frac{1}{3}AK$, and hence, by sim. triangles $EI = \frac{1}{3}EK$; consequently $FI = \frac{1}{2}EI = \frac{1}{6}EK = \frac{1}{5}FK = \frac{1}{10}(B-H)$; so that the common diameter $BL = FG - 2FI = B - \frac{1}{5}(B-H) = \frac{1}{5}(4B + H)$, which call c. Now by the rules of parabolic spindles and conic frustums we obtain (putting n for .7854) Fig. 44.

$$\frac{8\,B^2+4\,BC+3\,C^2}{15} \times \frac{L\,n}{3} = \frac{328\,B^2+44\,BH+3\,H^2}{25 \times 45} \times L\,n$$

for the parabolic or middle part; and

$$\frac{C^2+CH+H^2}{3} \times \frac{2\,L\,n}{3} = \frac{160\,B^2 \times 280BH + 310H^2}{25 \times 45} \times L\,n$$

for the two ends,

Of Gauging.

ends, and the sum of these two gives after proper reduction $(39B^2+26BH+25H^2)\times\frac{Ln}{90}$, nearly, for the content in inches. And the quantity $\frac{n}{90}$ or $\frac{.7854}{90}$ being divided by 231 gives $\frac{.00034}{9}$ the multiplier for wine gallons; and since 231 is to 282 as 9 to 11 nearly, $\frac{.00034}{11}$ will be the multiplier for ale gallons as in the rule.

Ex. Suppose a cask to have the same dimensions as in the four former rules; required the content?

Here $(39\times32^2+26\times32\times24+25\times24^2)\times40\times.00034=1010.5$; which being divided by 9 and by 11 we obtain 112.3 wine gallons or 91.9 ale gallons for the content required.

MEN

Menstrual ‖ Mentz.

MENSTRUAL, or MENSTRUOUS, in *Physiology*, is applied to the blood which flows from women in their ordinary monthly purgations. See MIDWIFERY and MEDICINE *Index*.

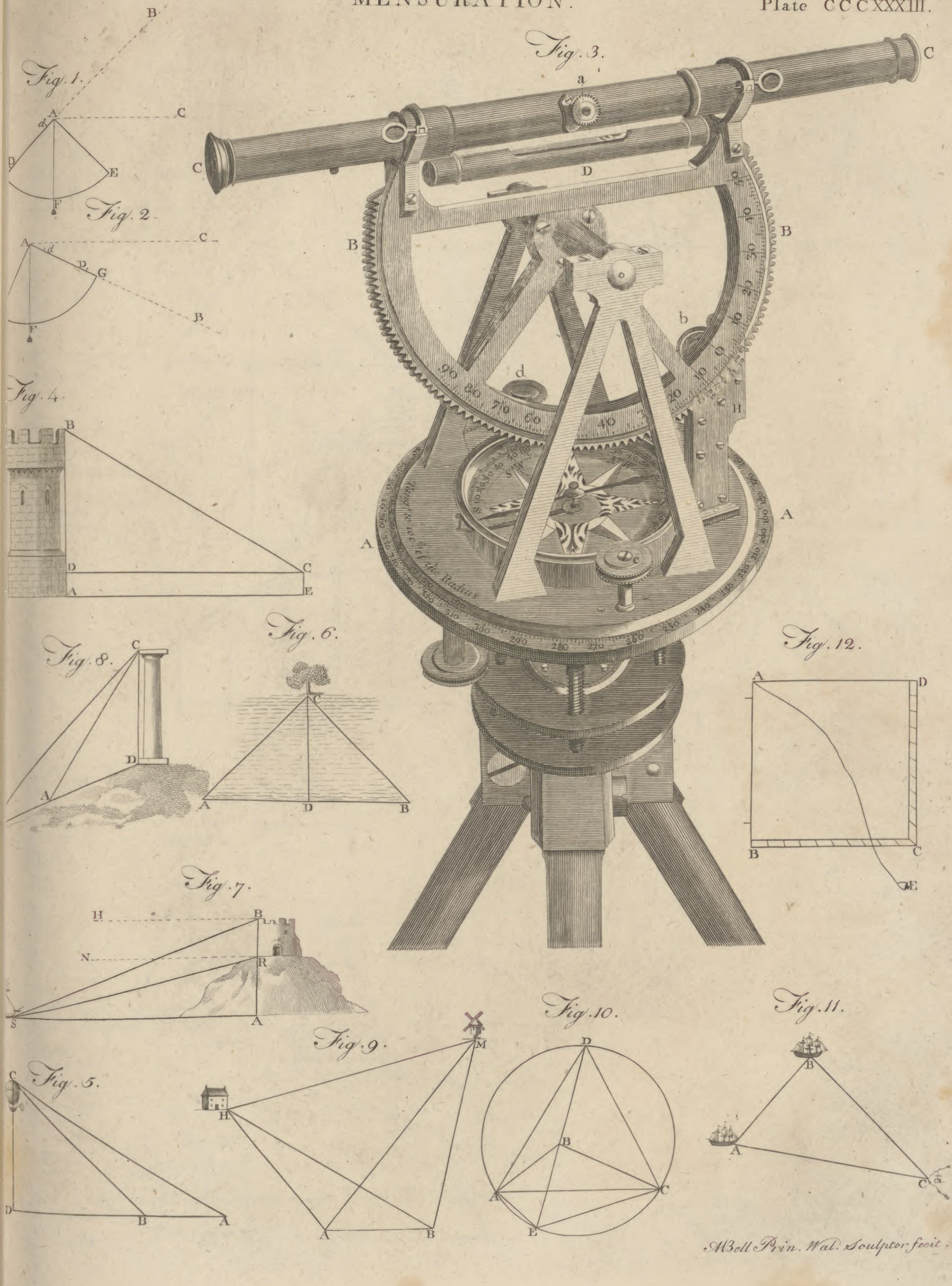
MENSTRUUM, in *Chemistry*, any body which in a fluid or subtilized state is capable of interposing its small parts betwixt the small parts of other bodies, so as to divide them subtly, and form a new uniform compound of the two.

MENTHA, MINT, a genus of plants belonging to the didynamia class, and in the natural method ranking under the 42d order, *Verticillatæ*. See BOTANY *Index*.

MENTOR, in fabulous history, a faithful friend of Ulysses; a son of Hercules; a king of Sidonia, who revolted against Artaxerxes Ochus, and afterwards was restored to favour by his treachery to his allies, &c. *Diod.* 16. An excellent artist in polishing cups and engraving flowers on them. *Plin.* 33. c. 11.—*Mart.* 9. ep. 60. v. 16.

MENTZ, an archbishopric, and formerly an electorate in Germany, the title of which was extinguished in 1802. It was situated on the banks of the river Maine, between Triers on the west, the Palatinate on the south, Franconia on the east, and the Wetterau on the north. It was about 60 miles in length from north-east to south-west, and about 50 in breadth. A considerable part of the elector's revenue arose from the toll on the Rhine and Maine, and from the tax on the excellent wines produced in this country. The chief towns of any trade are, 1. Mentz; (see the next article). In its neighbourhood is Hockheim, so celebrated for good wines, that the best Rhenish is from thence called *old Hock*. It is a pretty village, containing about 300 families; and belonged to the chapter of Mentz, the dean of which enjoyed the revenue of it. He and the Augustins of Mentz and Francfort had the exclusive enjoyment of the best Hockheimer wine, of which, in good years, a piece, consisting of 100 measures, sells for from 900 to 1000 guilders from the press. "This (says the Baron Riesbeck) is certainly one of the dearest wines in the world. Having a desire to taste it on the spot, we were obliged to pay a rixdollar; it was, however, of the best vintage in this century, viz. that of 1766. Nor should we have had it, but for an advocate of Mentz, to whom the hostess meant to shew favour. This was the first German wine I had met with which was entirely without any sour taste: it was quite a perfume to the tongue; whereas the other wine of Hockheim, let it be as good as it may, is not quite clear of vinegar; though for this also, if it has any age, you are forced to pay a guilder and a half." 2. Bingen is a pleasant town, which stands in the district called *Rhinegau*. This town, which, together with the toll on the Rhine, was worth about 30,000 guilders, belonged to the chapter of Mentz, is extremely beautiful, and contains about 4500 inhabitants. A great part of the corn which is carried into the Rhinegau from the neighbouring Palatinate, comes through this place, which, on the other hand, supplies the Palatinate with drugs, and various foreign commodities. This traffic alone would make the place very lively; but, besides this, it has very fruitful vineyards. The hill, at the foot of which it lies, and one side of which is made by the gullet through which the Nahe runs into the Rhine, forms another steep rock behind this gullet parallel to the Rhine and the golden Rudesheimer mountain; it therefore enjoys the same sun as this does, which makes the Budesheimer wine that grows on it little inferior to the true Rudesheimer. See RUDESHEIM. The rising grounds about it produce wines that are esteemed preferable to those of Baccharac, so much in vogue heretofore.—3. Elfeld, five miles west from Mentz, is a strong fortified town, on the north side of the Rhine, and the chief of the Rhinegau.—Here is Rudesheim, a place noted for the growth of the best wines in these parts. 4. Weisbaden lies between six and seven leagues from Francfort, and about five or six miles north of Mentz; it is the metropolis of a country belonging to the branch of Nassau-Saarbrak, and is famous for its mineral waters.

According to Riesbeck, the see of Mentz was indebted for its increase of riches to St Boniface, who may be called, with great justice, the apostle of the Germans. It was this man, an Englishman by birth, who in the time of Charlemagne baptized Witikind and the other brave Saxons who had so long resisted baptism with their swords, and spread the empire of the vicar of Jesus Christ as far as the northern and eastern seas. He it was who introduced the Roman liturgy into Germany, and made the savage inhabitants abstain from eating horse's flesh. He raised the papal power to a higher pitch than it had been raised in any other country in Christendom; and, in recompense of his services, the pope made all the new founded bishoprics in the north of Germany subject to the see of Mentz, which Boniface



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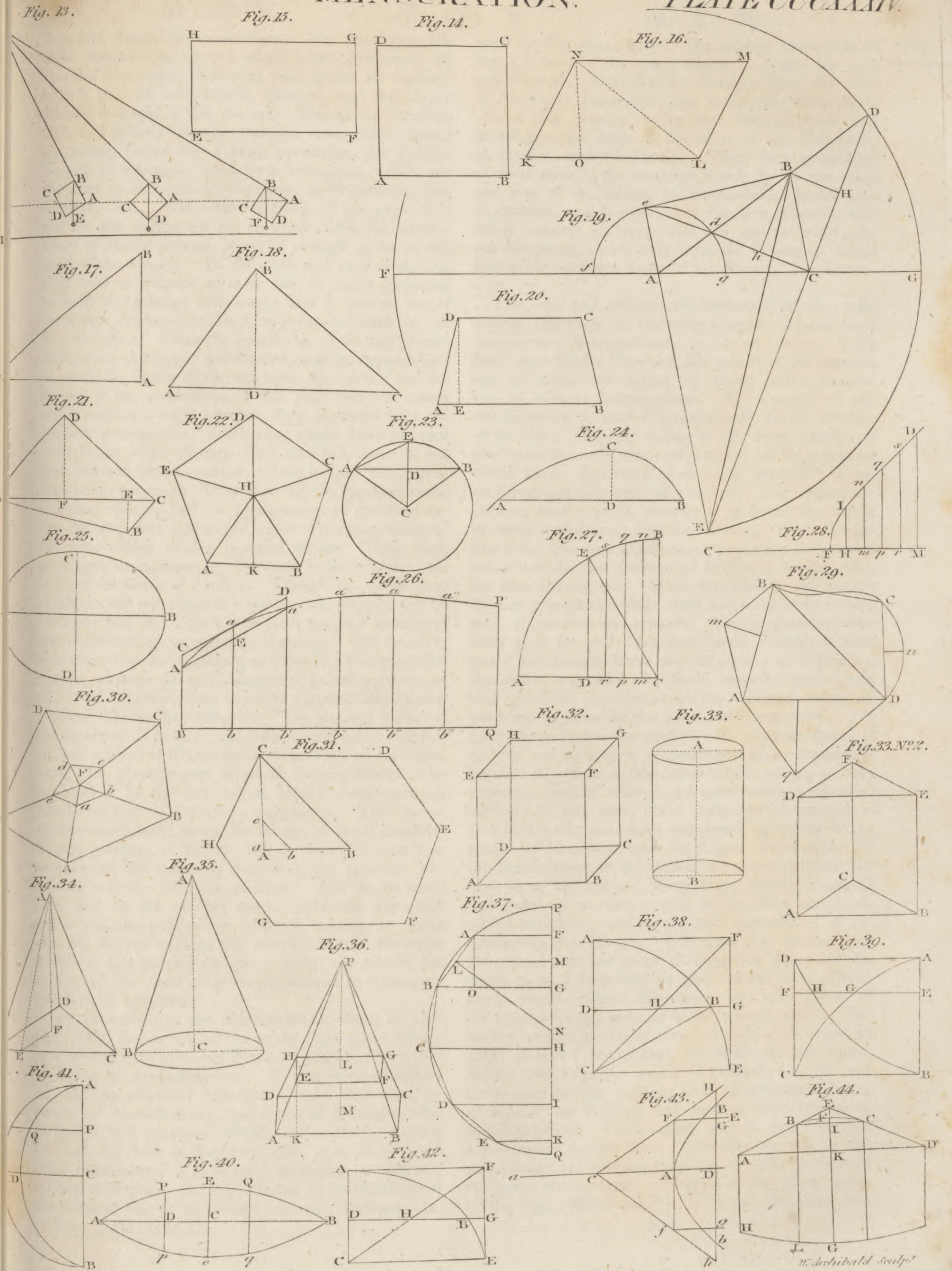
Fig. 13.
Fig. 15.
Fig. 14.
Fig. 16.
Fig. 19.
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Fig. 28.
Fig. 29.
Fig. 30.
Fig. 31.
Fig. 32.
Fig. 33.
Fig. 33. No. 2.
Fig. 34.
Fig. 35.
Fig. 36.
Fig. 37.
Fig. 38.
Fig. 39.
Fig. 41.
Fig. 40.
Fig. 42.
Fig. 43.
Fig. 44.
W. Archibald Sculpt.

Mentz.

face had chosen for his residence. The provinces, the most considerable in the whole papal dominions, all Suabia, Franconia, Bohemia, and almost all Saxony, with a part of Switzerland, Bavaria, and the Upper Rhine, belonged to this diocese. Though the reformation, and political changes lessened it one-third, it still contained, before the French revolution, the archbishopric of Sprengel, and eleven bishoprics, which are the most considerable of Germany, as Wurtsburg, Paderborn, &c. When the building of the papal monarchy was completed by Gregory VII. the archbishops of Mentz became powerful enough to be at the head of the empire. In the 13th and 14th centuries, they were so eminent as to be able to make emperors without any foreign assistance; and it was to one of them that the house of Hapsburg was indebted for its first elevation. After the boundaries of the two powers were more accurately ascertained, and the temporal got so much the better of the spiritual, the power and influence of the archbishops of this place were of course much reduced; still, however, they possessed very important prerogatives, which they might have exerted with much more efficacy than they did, were it not that various circumstances rendered them too dependent on the emperors. They were still the speakers in the electoral college, had the appointment of the diets under the emperors, and might order a re-examination of the proceedings of the imperial courts. These high privileges were, however, too much subject to the controul of the house of Austria. Though the archbishop of Mentz did not absolutely possess the largest, yet he certainly had the richest and most peopled domain of any ecclesiastical potentate in Germany. The country, it is true, does not contain more than 125 German miles square, whereas the archbishopric of Saltzburg contains 240; but then Saltzburg has only 250,000 inhabitants, whereas Mentz has 320,000. The natural riches of the territory of Mentz, and its advantageous situation, make a subject of Mentz much richer than one of Saltzburg, the greatest part of which is only inhabited by herdsmen. In the territory of Mentz there were 40 cities; in that of Saltzburg only seven. The tax on vessels which went down the Rhine, of itself produced 60,000 guilders or 6000l. a-year, which is nearly as much as all the mines of Saltzburg put together, excepting only the salt mine at Halle. The tax on wine, here and in the country round, produced the court above 100,000 guilders or 10,000l. a-year, in which sum we do not reckon the customs of the countries which lie at a greater distance. Upon the whole, the income of the archbishop might amount to 1,700,000 guilders, or 170,000l.

At the settling of the indemnities in 1802, all that part of the diocese which lay on the right of the Maine was given to the prince of Nassau-Usingen, except the bailiwick of Aschaffenburg. It was then determined that the electoral title should, from that time, be elector of Aschaffenburg, and count of Wetzlar; that he should still continue archchancellor of the empire, and hold his office at Ratisbon, with some abbeys and other indemnities, so as to yield an annual revenue of a million of florins. His jurisdiction as metropolitan of the German church to extend over all Germany, except the Prussian states. The noblest production of this territory is the wine, which is almost the only true Rhenish. Connoisseurs, indeed, allow the wines of Neirstein, Baccarach, and a very few other places out of this country, to be true Rhenish: but they do not give this name to the wines of the Palatinate, of Bardon, and of Alsatia. There is a great deal of wine made in the countries which lie on the south and west of the Rhine, at Laubenheim, Bodenheim. Budesheim, and Bingen; but the true Rhenish, that which inspires so many who are and so many who are not poets, comes only from the Rhinegau, which lies on the northern banks of the Rhine. See RHINEGAU.

The civil and military establishments of the archbishop, like those of the other German princes, were upon a scale disproportioned to his territories. "He has," says Baron Riesbeck, his ministers, his counsellors of state, and eighty or ninety privy counsellors of various denominations. The expence of this establishment is very disproportionate to the revenue of the state. This is owing to the large number of poor nobility, who can only accept of employments of this kind. Ignorance of the true principles of government are the causes of this evil. The consequences are, that a great number of persons, who might be usefully employed, live in idleness. Even the military establishment of the country appears to me more calculated for the purpose of feeding a hungry nobility than for real use. At the accession of the present elector, though the whole army only consisted of 2200 men, there were six generals. The regular establishment paid for and supported by the country is 8000 men; but though there are only 2000 men kept up, the money expended for their support, particularly that given to numberless useless officers, might be made use of more for the benefit of the country. The army of the archbishop consists of a German guard of 50 men and 25 horses, a Swiss guard, a squadron of hussars of 130 men (the most useful troops, as they purge the land of robbers and murderers), a corps of artillery of 104 men, three regiments of infantry of 600 men each, and some companies belonging to the armies of Franconia and the Upper Palatinate. Of the fortifications of the capital we may say much the same as of the army. Were they, indeed, improved and kept up as they ought to be, they would vie with Luxemburg, and be the most powerful of all the barriers against France. It is true, that the nature of the ground does not allow of a regular plan; but for single parts, I have seen no place of the same capabilities, where greater advantages has been taken of the ground for the erection of the several works. The beauty, as well as size of them, is indeed an object of great wonder; but though the circle of the Upper Rhine, and even the empire in general, has laid out great sums on the building these fortifications, parts of them are not finished, and parts of them are ready to fall to pieces. Their extent, indeed, would require a great army to man them. But this, as well as the maintaining and keeping them up, is evidently beyond the power of this court, or indeed of the whole circle of the Upper Rhine united. They are, therefore, also to

Mentz. to be looked upon as one of the things which serve more for magnificence than real use."

Mentz, a considerable town of Germany, in the circle of the Lower Rhine, and capital of the late electorate of the same name, is situated on the Rhine near its confluence with the Maine, 20 miles north-west of Worms, 15 west of Francfort, and 75 east of Triers, in E. Long. 8. 20. N. Lat. 40. 51. This city claims a right to the invention of the art of printing: (see *History of Printing*). Here is a very beautiful quay along the river, defended by several works well fortified with cannon. That part of the city which extends towards the river is most populous. The best vineyards for Rhenish wine being in this neighbourhood, Mentz has a flourishing trade in that commodity more particularly; and its commerce is the brisker, by reason that all the merchandise which passes up and down the Rhine stops in its harbour to change bottoms.

The northern part of the city, in which the archbishop resides, is full of very regular buildings. Here are three regular streets, called the *Blerchen*, which run parallel to each other from the banks of the Rhine to 600 yards within the city, and are cut almost regularly by very pretty cross streets. The archbishop's palace has a most commanding view of these streets, the Rhine, and the Rhinegau. There are also some good buildings in the old part of the city. The market of beasts is extremely well worth seeing; and you here and there meet with other agreeable spots. The market in the middle of the town, though not regular, is one of the prettiest places in Germany. The cathedral is well worth notice. It is an immense large old Gothic building, the spire of which was struck with lightning many years ago, and entirely laid in ashes. As it contained much wood, it burned 14 hours before it was entirely consumed. To prevent these accidents for the future, the chapter had the present one built to the same height in stone, an undertaking which cost them 40,000 guilders or 4000l. It is a great pity (Baron Riesbeck observes) that it is overloaded with small ornaments: and a still greater, that this wonderful edifice is so choked up with shops and houses as to be hardly more than half visible. As, however, houses and shops are very dear in this part of the town, one cannot be very angry with the chapter for choosing rather to make the most of its ground, than to show off the church to the best advantage. The rent of a shop and a single room to live in is 150 guilders or 15l. per annum in this part of the town. There is hardly another church in Germany of the height and length of this cathedral; and the inside of it is decorated with several magnificent monuments of princes and other great personages. Besides the cathedral, the city of Mentz contains several other churches in the modern style, very well worth seeing. St Peter's, and the Jesuits church, though both too much loaded with ornament, are among this number. The church of the Augustins, of which the inhabitants of Mentz are so proud, is a masterpiece of bad taste; but that of Ignatius, though little is said about it, would be a model of the antique, if here likewise there had not been too much ornament lavished. Upon the whole, the palaces of the noblesse want that noble simplicity which alone constitutes true beauty and magnificence. In another century the externals of the city will be quite changed. The late prince built a great deal, and the present has a taste for the same sort of expence. The monks and governors of hospitals also have been forced to rebuild their houses; so that when a few more streets are made broader and straighter, the whole will have no bad appearance. The inhabitants, who together with the garrison amount to 30,000, are a good kind of people, and, like all the catholics of Germany, make great account of a good table. Their faces are interesting, and they are not deficient either in wit or activity.

There are few cities in Germany besides Vienna which contain so rich and numerous a nobility as this does: there are some houses here which have estates of 100,000 guilders, or 10,000l. a-year. The counts of Bassenheim, Schonborn, Stadion, Ingelheim, Elz, Ostein, and Walderdorf, and the lords of Dahlberg, Breitenbach, with some others, have incomes of from 30,000 to 100,000 guilders. Sixteen or eighteen houses have from 15,000 to 30,000 guilders annual revenue. The nobility of this place are said to be some of the oldest and most untainted in Germany. There are amongst them many persons of extraordinary merit, who join uncommon knowledge to all the duties of active life. Upon the whole, they are far superior to the greater part of the German nobility. Their education, however, is still too stiff. The first minister of the court was refused admittance into their assemblies for not being sufficiently noble; and they think they degrade themselves by keeping company with bourgeois.

The clergy of this place are the richest in Germany. A canonry brings in 3500 Rhenish guilders in a moderate year. The canonry of the provost brings him in 40,000 guilders a-year; and each of the deaneries is worth 2600 guilders. The income of the chapter altogether amounts to 300,000 guilders. Though it is forbidden by the canons of the church for any one to have more than a single prebend, there is not an ecclesiastic in this place who has not three or four; so that there is hardly a man amongst them who has not at least 8000 guilders a-year. The last provost, a count of Elz, had prebends enough to procure him an income of 75,000 guilders. Exclusive of the cathedral, there are several other choirs in which the canonries bring in from 1200 to 1500 guilders a-year. To give an idea of the riches of the monasteries of this place, Baron Riesbeck informs us, that at the destruction of the Jesuits, their wine, which was reckoned to sell extremely cheap, produced 120,000 rixdollars. A little while ago the elector abolished one Carthusian convent and two nunneries, in the holy cellars of which there was found wine for at least 500,000 rixdollars. "Notwithstanding this great wealth (continues our author), there is not a more regular clergy in all Germany. There is no diocese, in which the regulations made by the council of Trent have been more strictly adhered to than they have here; the archbishops having made a particular point of it both at the time of the reformation and ever since. One thing which greatly contributes to keep up discipline is the not suffering any priest to remain in the country who

who has not fixed and stated duties, and a revenue annexed to them. Most of the irregularities in Bavaria, Austria, and other countries, arise from abbés who are obliged to subsist by their daily industry and any masses which they can pick up. These creatures are entirely unknown here. The theological tenets of this court are also much purer than those of any other ecclesiastical prince in Germany. I was pleased to see the Bible in the hands of so many common people, especially in the country. I was told that the reading of it was not forbidden in any part of the diocese; only persons were enjoined not to read it through, without the advice of their confessors. For a long time superstition has been hunted through its utmost recesses; and though it is not quite possible to get entirely clear of pilgrimages and wonder-working images, you will meet with no priest bold enough to exercise or to preach such nonsense as we hear in the pulpits of other German churches."

Though the trade of this place has been constantly on the increase for these 18 or 20 years past, yet it is by no means what it ought to be from the situation and other advantages. The persons here who call themselves merchants, and who make any considerable figure, are in fact only brokers. A few toy-shops, five or six druggists, and four or five manufacturers of tobacco, are all that can possibly be called traders. There is not a banker in the whole town; and yet this country enjoys the staple privilege, and commands by means of the Maine, Necker, and Rhine, all the exports and imports of Alsatia, the Palatinate, Franconia, and a part of Suabia and Hesse, as far as the Netherlands. The port too is constantly filled with ships, but few of them contain any merchandise belonging to the inhabitants of the place. The French took it by surprise in October 1792; it surrendered to the king of Prussia in 1793; but the French again got possession of it in October 1797; and it continued united to the French empire till 1814, when it passed into the hands of the allies. It now forms a part of Germany.

MENTZEL, Christian, born at Frustenwall in the Mittel-mark, is celebrated for his skill in medicine and botany, in pursuit of which he travelled through many countries. He had correspondents in the most distant parts of the world. He died A. D. 1701 about the 79th year of his age. He was a member of the academy *des Curieux de la Nature*. His works are, 1. *Index nominum plantarum*, printed at Berlin in folio, 1696; and reprinted with additions in 1715, under the title of *Lexicon plantarum polyglotton universale*. 2. A Chronology of China, in German, printed at Berlin 1696, in 4to. The following manuscripts of his composition are preserved in the royal library at Berlin. 1. *Sur l'Histoire Naturelle du Brasil*, in four volumes folio. 2. *Sur les Fleurs et les Plantes du Japon*, with coloured plates, two vols folio.

MENUS, in *Ancient Geography*, a river of Germany; now the *Maine*, rising in Franconia, and running from east to west into the Rhine at Mentz.

MENUTHIAS, in *Ancient Geography*, an island adjoining to the north-east of the promontory Prasum of Ethiopia beyond Egypt. Some take it to be *Madagascar*, or the island *St Laurence*. Isaac Vossius will have it to be *Zanzibar*; Madagascar being at a greater distance from the continent than the ancients ever sailed to, whereas Menuthias was nearer: yet though Zanzibar be nearer the continent, it is however nearer the equator than Ptolemy's Menuthias, placed in south latitude 12⅙ degrees.

MENYANTHES, Marsh-trefoil, or *Bogbean*; a genus of plants belonging to the pentandria class; and in the natural method ranking under the 21st order, *Preciæ*. See Botany *Index*.

MENZIKOFF, Alexander, was originally an apprentice to a pastry-cook near the palace of Moscow; but by a fortunate circumstance was drawn from that situation in early life, and placed in the household of Peter the Great. Having made himself master of several languages, and being formed for war and for business, he first rendered himself agreeable, and afterwards became necessary to his master. He assisted Peter in all his projects; and was rewarded for his services with the government of Ingria, the rank of prince, and the title of *major-general*. He signalized himself in Poland in 1708 and 1709; but in 1713 he was accused of embezzling the public money, and fined in 300,000 crowns. The czar remitted the fine; and having restored him to favour, gave him the command of an army in the Ukraine in 1719, and sent him as his ambassador into Poland in 1722. Constantly employed about the means of preserving his influence after the death of his master, who was then evidently on the decline, Menzikoff discovered the person to whom the czar intended to leave the succession. The emperor was highly offended, and his penetration cost him the principality of Plescoff. Under the czarina Catherine, however, he was higher in favour than ever; because, on the death of the czar in 1725, he was active in bringing different parties in Russia to agree to her succession. This princess was not ungrateful. In appointing her son-in-law Peter II. to be her successor, she commanded him to marry the daughter of Menzikoff, and gave the czar's sister to his son. The parties were actually betrothed: and Menzikoff was made duke of Cozel and grand steward to the czar. But this summit of elevation was the prelude to his fall. The *Dolgoroukis*, favourites of the czar, had influence enough to procure his banishment, together with that of his family, to one of his own estates at the distance of 250 leagues from Moscow. He had the imprudence to leave the capital with the splendor and magnificence of a governor going to take possession of his province. His enemies took advantage of this circumstance to inflame the indignation of the czar. At some distance from Moscow he was overtaken by a detachment of soldiers. The officer who commanded them made him alight from his chariot, which he sent back to Moscow; and placed him and his whole family in covered waggons, to be conducted into Siberia, in the habit of peasants. When he arrived at the place of his destination, he was presented with cows and sheep big with young, and poultry, without knowing from whom he received the favour. His house was a simple cottage; and his employment was to cultivate the ground, or to superintend its cultivation. New causes of sorrow were added to the severities of exile. His wife died in the journey; he had the misfortune to lose one of his daughters by the smallpox; and his other two children were seized with the same disease, but recovered. He sunk under his misfortunes, November 2. 1729; and was buried beside his daughter, in a little chapel which he had built. His misfortunes had inspired him with sentiments of devotion, which, amid the splendor of his former situation, he had altogether neglected. His two surviving children enjoyed greater liberty after the death of their father. The officer permitted them to attend public worship on Sundays by turns. One day when his daughter was returning from the village, she heard herself accosted by a peasant from the window of a cottage, and, to her great surprise, recognised in this peasant the persecutor of her family, Dolgorouki; who, in his turn, had fallen a sacrifice to the intrigues of the court. She communicated this intelligence to her brother, who could not behold, without emotion, this new instance of the vanity and instability of honours and power. Young Menzikoff and his sister were soon after recalled to Moscow by the czarina Ann; and left Dolgorouki in possession of their cottage. He was made captain of the guards, and received the fifth part of his father's possessions. His sister was appointed maid of honour to the empress, and afterwards married to great advantage.

MENZINI, Benedict, a celebrated Italian poet, born at Florence, was professor of eloquence at the college Della Sapienza at Rome, where he died in 1704. He wrote, 1. The art of poetry. 2. Satires, elegies, hymns, and the Lamentations of Jeremiah. 3. *Academia Tusculana*, a work in verse and prose, which passes for his masterpiece.

MEOTIS, or Palus Meotis, a sea of Turkey, which divides Europe from Asia; extending from Crim Tartary to the mouth of the river Don or Tanais.

MEPHITIC, a name expressing any kind of noxious vapour; but generally applied to that species of vapour called *fixed air*. See Carbonic Acid, Chemistry *Index*.

MEPHITIS fanum, a temple erected to the goddess Mephitis, near Lacus Amsancti; who was worshipped also at Cremona. Figuratively, *Mephitis* denotes a noisome or pestilential exhalation, (Virgil).

MEQUINEZ, or Miquinez, the northern capital of the Morocco empire, stands at the extremity of the province of Beni Hassen, 80 leagues north from the city of Morocco (which is the southern imperial city), and 20 to the east of Sallee and the ocean. Maknassa, its founder, built it first at the bottom of a valley; but Muley Ismael extended it considerably over the plain that lies to the west of the valley. It is surrounded with well cultivated fields and hills, adorned with gardens and olive plantations, and abundantly watered with rivulets. Accordingly, fruits and kitchen stuffs thrive here exceedingly, and even the superior urbanity of the inhabitants announces the temperature of the climate. The winter indeed is very inconvenient, on account of the dirtiness of the town, the streets not being paved, and the soil being slimy.

Mequinez is surrounded with walls; the palace itself is fortified with two bastions, on which formerly some small guns were mounted. Muley Ismael, and Muley Abdallah, often in this city resisted the efforts of the Brebes, the sworn enemies of their tyranny. To the west are seen some walls of circumvallation, six feet in height, which were probably mere intrenchments for the infantry; the attacks of the Brebes being only sudden and momentary inroads, which did not require a long defence. There is at Mequinez, as well as at Morocco, a walled and guarded suburb for the Jews. The houses are neater here than at Morocco. The Jews here are more numerous; and they can turn their industry to greater account, because the Moors in this city are more polished, and (being nearer to Europe) more visited, than those in the southern parts. Near the Jewry, there is another enclosed and separate quarter, called the *Negro town*. It was built by Muley Ismael, for the accommodation of those black families which composed his soldiery. This town is now uninhabited, as are all those destined for the same use through the rest of the empire.

At the south-east extremity of the city stands the palace of the emperor, which was built by Muley Ismael. The space occupied by this palace is very great; it includes several gardens, elegantly disposed, and well watered. There is a large garden in the centre, surrounded by a vast and pretty regular gallery resting on columns, which communicates with the apartments. Those of the women are very spacious, and have a communication with a large chamber which looks into the garden. As you pass from one apartment to another, you find at intervals regular courts paved with square pieces of black and white marble; in the middle of these courts is a marble basin, from the centre of which rises a *jet d'eau*, and the water falls down into this basin. These fountains are numerous in the palace; they are useful for domestic purposes, and they serve for the ablutions, which the scruples of the Mahometans have exceedingly multiplied. The palaces of the Moorish kings are large, because they are composed only of one range of apartments; these are long and narrow, from 18 to 20 feet high; they have few ornaments, and receive the light by two large folding doors, which are opened more or less as occasion requires. The rooms are always lighted from a square court in the centre, which is generally encompassed with a colonnade.

The Moors here are more courteous than those in the southern parts; they are civil to strangers, and invite them into their gardens, which are very neat. The women in this part of the empire are beautiful; they have a fair complexion, with fine black eyes, and white teeth. I have sometimes seen them taking the air on the terraces; they do not hide themselves from Europeans, but retire very quickly on the appearance of a Moor.

MERA-de-Asta, formerly a large town of Andalusia, seated on the river Guadaleta, between Arcos and Xeres de la Frontera; but now only a large heap of ruins. Here the Arabs conquered Roderick the last king of the Goths, and by that victory became masters of Spain in 713.

MERCATOR, Gerard, one of the most celebrated geographers of his time, was born at Ruremonde in 1512. He applied himself with such industry to geography and mathematics, that he is said to have frequently forgot to eat and drink. The emperor Charles V. had a particular esteem for him, and the duke of Juliers made him his cosmographer. He composed a chronology, some geographical tables, an atlas, &c. engraving and colouring the maps himself. He died in 1594. His method of laying down charts is still used, and bears the name of *Mercator's charts*.

MERCATOR, *Nicholas*, an eminent mathematician in the 17th century, was born at Holstein in Denmark; and came to England about the time of the restoration, where he lived many years. He was fellow of the Royal Society; and endeavoured to reduce astrology to rational principles, as appeared from a MS. of his in the possession of William Jones, Esq. He published several works, particularly *Cosmographia*. He gave the quadrature of the hyperbola by an infinite series; which was the first appearance in the learned world of a series of this sort drawn from the particular nature of the curve, and that in a manner very new and abstracted.

MERCATOR's Sailing, that performed by Mercator's chart. See NAVIGATION.

MERCATORUM FESTUM, was a festival kept by the Roman merchants on the 15th of May, in honour of Mercury, who presided over merchandise. A sow was sacrificed on the occasion, and the people present sprinkled themselves with water fetched from the fountain called *aqua Mercurii;* the whole concluding with prayers to the god for the prosperity of trade.

MERCHANT, a person who buys and sells commodities in gross, or deals in exchanges; or that traffics in the way of commerce, either by importation or exportation. Formerly every one who was a buyer or seller in the retail way was called a *merchant*, as they still are both in France and Holland; but here shopkeepers, or those who attend fairs or markets, have lost that appellation.

Previous to a person's engaging in a general trade, and becoming an universal dealer, he ought to treasure up such a fund of useful knowledge as will enable him to carry it on with ease to himself, and without risking such losses as great ill-concerted undertakings would naturally expose him to. A merchant should therefore be acquainted with the following parts of commercial learning: 1. He should write properly and correctly. 2. Understand all the rules of arithmetic that have any relation to commerce. 3. Know how to keep books of double and single entry, as journals, a leger, &c. 4. Be expert in the forms of invoices, accounts of sales, policies of insurances, charter-parties, bills of lading, and bills of exchange. 5. Know the agreement between the money, weights, and measures of all parts. 6. If he deal in silk, woollen, linen, or hair manufactures, he ought to know the places where these different sorts of merchandises are manufactured, in what manner they are made, what are the materials of which they are composed, and from whence they come, the proportions of these materials before working up, and the places in which they are sent after their fabrication. 7. He ought to know the lengths and breadths which silk, woollen, or hair stuffs, linen, cottons, fustians, &c. ought to have according to the several statutes and regulations of the places where they are manufactured, with their different prices, according to the times and seasons; and if he can add to his knowledge the different dyes and ingredients which form the various colours, it will not be useless. 8. If he confines his trade to that of oils, wines, &c. he ought to inform himself particularly of the appearances of the succeeding crops, in order to regulate his disposing of what he has on hand; and to learn as exactly as he can what they have produced when got in, for his direction in making the necessary purchases and engagements. 9. He ought to be acquainted with the sorts of merchandise found more in one country than another, those which are scarce, their different species and qualities, and the properest method for bringing them to a good market either by land or sea. 10. To know which are the merchandises permitted or prohibited, as well on entering as going out of the kingdoms or states where they are made. 11. To be acquainted with the price of exchange, according to the course of different places, and what is the cause of its rise and fall. 12. To know the customs due on importation or exportation of merchandises, according to the usage, the tariffs, and regulations of the places to which he trades. 13. To know the best manner of folding up, embaling, or tunning, the merchandises for their preservation. 14. To understand the price and condition of freighting and insuring ships and merchandise. 15. To be acquainted with the goodness and value of all necessaries for the construction and repairs of shipping, the different manner of their building; what the wood, the masts, cordage, cannons, sails, and all requisites, may cost. 16. To know the wages commonly given to the captain, officers, and sailors, and the manner of engaging with them. 17. He ought to understand the foreign languages, or at least as many of them as he can attain to; these may be reduced to four, viz. the Spanish, which is used not only in Spain but on the coast of Africa, from the Canaries to the Cape of Good Hope: the Italian, which is understood on all the coasts of the Mediterranean, and in many parts of the Levant: the German, which is understood in almost all the northern countries; and the French, which is now become almost universally current. 18. He ought to be acquainted with the consular jurisdiction, with the laws, customs, and usages of the different countries he does or may trade to; and in general all the ordinances and regulations both at home and abroad that have any relation to commerce. 19. Though it is not necessary for a merchant to be very learned, it is proper that he should know something of history, particularly that of his own country; geography, hydrography, or the science of navigation; and that he be acquainted with the discoveries of the countries in which trade is established, in what manner it is settled, of the companies formed to support those establishments, and of the colonies they have sent out.

All these branches of knowledge are of great service to a merchant who carries on an extensive commerce; but if his trade and his views are more limited, his learning and knowledge may be so too; but a material requisite for forming a merchant is, his having on all occasions a strict regard to truth, and his avoiding fraud and deceit as corroding cankers that must inevitably destroy his reputation and fortune.

Trade is a thing of so universal a nature, that it is impossible for the laws of Britain, or of any other nation, to determine all the affairs relating to it; therefore all nations, as well as Great Britain, show a particular regard to the law-merchant, which is a law made by the merchants among themselves: however, merchants and other strangers are subject to the laws of the country in which they reside. Foreign merchants are to sell their merchandise at the port where they land, in gross, and not by retail: and they are allowed to be paid in gold or silver bullion, in foreign coin or jewels, which may be exported. If a difference arises between the king and any foreign state, the merchants of that state are allowed six months time to sell their effects and leave the kingdom; during which time they are to remain free and unmolested in their persons and goods. See the articles COMMERCE and *Mercantile Law*.

MERCHET (MERCHETUM), a fine or composition paid by inferior tenants to the lord, for liberty to dispose of their daughters in marriage. No baron, or military tenant, could marry his sole daughter and heir, without such leave purchased from the king *pro maritanda filia*. And many of our servile tenants could neither send their sons to school, nor give their daughters in marriage, without express leave from the superior lord. See Kennet's Glossary *in Maritagium*. See also MARCHET, under which word it is stated, and very generally understood, that this was a right claimed by the lord of the manor in the time of the feudal system of passing the first night after marriage with his female villain. According to Mr Astle, the mercheta was a compact between the lord and his vassal for the redemption of an offence committed by the vassal's unmarried daughter; and also a fine paid by a sokeman or a villain to his lord for permission to marry his daughter to a free man; and in cases where the vassal gave away his daughter without having obtained this license, he subjected himself to a heavier fine.

MERCIA, the name of one of the seven kingdoms founded in England by the Saxons. Though the latest formed, it was the largest of them all, and grew by degrees to be by far the most powerful. On the north it was bounded by the Humber and the Mersey, which separated it from the kingdom of Northumberland; on the east by the sea, and the territories of the East Angles and Saxons; on the south by the river Thames; and on the west by the rivers Severn and Dee. It comprehended well nigh 17 of our modern counties, being equal in size to the province of Languedoc in France; very little, if at all, less than the kingdom of Arragon in Spain; and superior in size to that of Bohemia in Germany.

Penda is regarded as its first monarch; and the kingdom is thought to derive its name from the Saxon word *merc*, which signifies "a march, bound, or limit," because the other kingdoms bordered upon it on every side; and not from the river Mersey, as some would persuade us. Penda assumed the regal title A. D. 626, and was of the age of 50 at the time of his accession; after which he reigned near thirty years. He was of a most furious and turbulent temper, breaking at different times with almost all his neighbours, calling in the Britons to his assistance, and shedding more Saxon blood than had been hitherto spilled in all their intestine quarrels. He killed two kings of Northumberland, three of the East Angles, and compelled Kenwall king of the West Saxons to quit his dominions. He was at length slain, with most of the princes of his family, and a multitude of his subjects, in a battle fought not far from Leeds, by Oswy king of Northumberland. This battle, which the Saxon chronicle tells us was fought at Winwidfield, A. D. 655, made a great change in the Saxon affairs, which the unbridled fury of Penda had thrown into great confusion. He had the year before killed Anna king of the East Angles in battle, whose brother Ethelred notwithstanding took part with Penda. On the other hand, Penda, the eldest son of Penda, to whom his father had given the ancient kingdom of the Mid Angles, had two years before married the natural daughter of King Oswy, and had been baptized at his court. At that time it should seem that Oswy and Penda were upon good terms; but after the latter had conquered the East Angles, he resolved to turn his arms against the kingdom of Northumberland. Oswy by no means had provoked this rupture; on the contrary, Bede tells us that he offered large sums of money, and jewels of great value, to purchase peace: these offers being rejected, he was reduced to the necessity of deciding the quarrel by the sword. The river near which the battle was fought overflowing, there were more drowned than killed. Amongst these, as the Saxon chronicle says, there were thirty princes of the royal line, some of whom bore the title of *kings*; and also Ethelred king of the East Angles, who fought on the side of Penda against his family and country.

His son Penda, who married the daughter of that conqueror became a Christian, and was not long after murdered, as is said, by the malice of his mother. His brother Wolfher becoming king of Mercia, embraced in process of time the faith of the gospel, and proved a very victorious and potent monarch; and is, with no fewer than seven of his immediate successors, commonly styled *king of the Anglo-Saxons*, though none of them are owned in that quality by the Saxon chronicle. But though possibly none of them might enjoy this honour, they were undoubtedly very puissant princes, maintaining great wars, and obtaining many advantages over the sovereigns of other Saxon states, and especially the East Angles, whom they reduced. The extent of the Mercian territories was so ample as to admit, and so situated as to require, the constituting subordinate rulers in several provinces; to whom, especially if they were of the royal line, they gave the title of *kings*; which occasions some confusion in their history. Besides the establishing episcopal sees and convents, the Saxon monarchs took other methods for improving and adorning their dominions; and as Mercia was the largest, so these methods were most conspicuous therein. Coventry, as being situated in the centre, was usually, but not always, the royal residence. Penda, who was almost continually in a state of war, lived as his military operations directed, in some great town on the frontiers. Wolfher built a castle or fortified palace for his own residence, which bore his name.—Offa kept his court at Sutton Walls near Hereford.

In each of the provinces there resided a chief magistrate; and if he was of the royal blood, had usually the title of *king*. Penda, at the time he married Oswy's daughter, had the title of *king of Leicester*.—

Ethelred

Ethelred made his brother Merowald king of Hereford; who, dying without issue, bequeathed it to his younger brother Mereelm. The like honours were sometimes conferred upon the princesses; and hence, in Mercia especially, we occasionally read of *vice-queens.* By these means the laws were better executed, the obedience of the subjects more effectually secured, and the splendour of these residences constantly kept up and augmented.

At length the crown devolving sometimes on minors and sometimes on weak princes, intestine factions also prevailing, the force of this hitherto mighty kingdom began sensibly to decline. This falling out in the days of Egbert, the most prudent as well as the most potent monarch of the West Saxons, he took advantage of these circumstances; and having encouraged the East Angles to make an attempt for the recovery of their independence, he, in a conjuncture every way favourable to his design, broke with the Mercians, and after a short war obliged them to submit. But this was not an absolute conquest, the kings of Mercia being allowed by him and his successors to retain their titles and dominions, till the invasion of the Danes put an end to their rule, when this kingdom had subsisted above 250 years; and when the Danes were afterwards expelled by the West Saxons, it sunk into a province, or rather was divided into many.

MERCURIAL, something consisting of, or relating to, mercury.

MERCURIALIS, DOGS MERCURY; a genus of plants belonging to the diœcia class; and in the natural method ranking under the 38th order, *Tricoccæ.* See BOTANY *Index.*

MERCURIFICATION, in metallurgic chemistry, the obtaining the mercury from metallic minerals in its fluid form. See CHEMISTRY and MINERALOGY *Index.*

MERCURY, or QUICKSILVER. See CHEMISTRY and MINERALOGY *Index.*

MERCURY, in the heathen mythology. See HERMES.

Most of the actions and inventions of the Egyptian Mercury have likewise been ascribed to the Grecian, who was said to be the son of Jupiter and Maia, the daughter of Atlas. No one of all the heathen divinities had so many functions allotted to him as this god: he had constant employment both day and night, having been the common minister and messenger of the whole Pantheon; particularly of his father Jupiter, whom he served with indefatigable labour, and sometimes, indeed, in a capacity of no very honourable kind. Lucian is very pleasant upon the multitude of his avocations; and according to the confession of the emperor Julian, Mercury was no hero, but rather one who inspired mankind with wit, learning, and the ornamental arts of life, than with courage. The pious emperor, however, omits some of his attributes; for this god was not only the patron of trade, but also of theft and fraud.

Amphion is said, by Pausanias, to have been the first that erected an altar to this god; who, in return, invested him with such extraordinary powers of music (and masonry), as to enable him to fortify the city of Thebes in Bœotia, by the mere sound of his lyre.

Horace gives us the best part of his character:

Thou god of wit, from Atlas sprung,
Who by persuasive pow'r of tongue,
And graceful exercise, refin'd
The savage race of human kind,
Hail! winged messenger of Jove,
And all th' immortal pow'rs above.
Sweet parent of the bending lyre,
Thy praise shall all its sounds inspire.
  Artful and cunning to conceal
Whate'er in sportive theft you steal,
When from the god who gilds the pole,
E'en yet a boy, his herds you stole;
With angry voice the threat'ning power
Bade thee thy fraudful prey restore;
But of his quiver too beguil'd,
Pleas'd with the theft, Apollo smil'd.
  You were the wealthy Priam's guide,
When safe from Agamemnon's pride,
Through hostile camps, which round him spread
Their watchful fires, his way he sped.
Unspotted spirits you consign
To blissful seats and joys divine;
And, pow'rful, with thy golden wand,
The light, unbodied crowd command;
Thus grateful does thy office prove
To gods below, and gods above. FRANCIS.

This ode contains the substance of a very long hymn to Mercury, attributed to Homer. Almost all the ancient poets relate the manner in which the Grecian Mercury discovered the lyre; and tell us that it was an instrument with seven strings; a circumstance which makes it essentially different from that said to have been invented by the Egyptian Mercury, which had but three. However, there have been many claimants besides Mercury to the seven-stringed lyre. See LYRE.

His most magnificent temple was on Mount Cylene, in Arcadia. He is described by the poets as a fair beardless youth, with flaxen hair, lively blue eyes, and a smiling countenance. He has wings fixed to his cap and sandals, and holds the caduceus (or staff surrounded with serpents, with two wings on the top), in his hand; and is frequently represented with a purse, to show that he was the god of gain. The animals sacred to him, were the dog, the goat, and the cock. In all the sacrifices offered to him, the tongues of the victims were burnt; and those who escaped imminent danger sacrificed to him a calf with milk and honey.

MERCURY, ☿ in *Astronomy.* See ASTRONOMY *Index.*

This planet is brightest between his elongations and superior conjunction, very near to which last he can generally be seen. He becomes invisible soon after he has found his elongation, going towards his inferior conjunction; and becomes visible again a few days before his next elongation. The brightness of this planet alters sometimes very considerably in 24 hours. It has been observed when less than three degrees distant from the sun, and may, perhaps, sometimes be seen even in conjunction with it.

Mercury and Venus appear brightest and most beautiful in the opposite parts of their orbits; the first, between

tween his elongations and superior conjunction; and the other, between her elongations and inferior conjunction. Therefore, Venus is seen in great perfection as a crescent, particularly in her inferior conjunction, whilst Mercury is seldom seen in such perfect phases. Mercury should be always observed on or near the meridian. When farthest from the sun, he always appears with a very faint light; and when he has a great south declination, or the atmosphere is not perfectly clear, he seldom can be seen in those parts of his orbit, where he only begins to recover his brightness, or where it is much diminished. He has frequently been seen on the meridian even with a small telescope and small power; and it appears from the above statement that he may be obscured in a clear day rather more than half his orbit, or near one hundred and fourscore days in the year.

MERCURY, in *Heraldry*, a term used in blazoning by planets, for the purple colour used in the arms of sovereign princes.

MERCY, a virtue that inspires us with compassion for our brethren, and which inclines us to give them assistance in their necessities. Mercy is also taken for those favours and benefits that we receive either from God or man, particularly in the way of forgiveness of injuries or of debts. Nothing can be more beautiful than the description of mercy given us by Shakespeare, in the pleading between Portia and the Jew:

Por. Then must the Jew be merciful.
Shy. On what compulsion must I? tell me that.
Por. The quality of mercy is not strain'd;
It droppeth as the gentle rain from heav'n
Upon the place beneath. It is twice bless'd:
It blesseth him that gives, and him that takes.
'Tis mightiest in the mightiest; it becomes
The throned monarch better than his crown:
The sceptre shows the force of temporal power,
The attribute to awe and majesty,
Wherein doth sit the dread and fear of kings;
But mercy is above this scepter'd sway,
It is enthroned in the heart of kings;
It is an attribute to God himself,
And earthly power doth then show likest God's,
When mercy seasons justice. Therefore, Jew,
Though justice be thy plea, consider this,
That in the course of justice none of us
Should see salvation. We do pray for mercy;
And that same prayer doth teach us all to render
The deeds of mercy. *Merchant of Venice*, act iv.

MERCY-SEAT, or PROPITIATORY, in Jewish antiquity, the covering of the ark of the covenant.—The Hebrew name of this cover, which we translate mercy-seat, is *Capporeth* (Exod. xxv. 17. 22.), from *Cappor*, which signifies *to cover*, *to shut up*, *to expiate*, *to pay*. This cover was of gold, and at its two ends were fixed the two cherubims of the same metal, which by their wings extended forwards, seemed to form a throne for the majesty of God, who in scripture is represented to us as sitting between the cherubims, and the ark itself was as it were his footstool. It was from hence that God gave his oracles to Moses, or to the high priest that consulted him, (Exod. xxv. 22. Numb. vii. 89.).

MERETRIX, among the Romans, differed from the *prostibula*. The *prostibulæ* were common courtesans, with bills over their doors, signifying their profession, and were ready at all times to entertain customers; whereas the *meretrices* entertained none but at night.—The *meretrices* differed in their dress from the *matrons*; the former wore the *toga* and short *tunics*, like those of the men: the latter wore the *palla* and the *stola* of such a length as to reach to their feet.

MERGANSER. See MERGUS.

MERGUS, a genus of birds of the order of anseres. See ORNITHOLOGY *Index*.

MERIAN, MARIA SIBYLLA, a celebrated paintress, born at Frankfort in 1647, was the daughter of Matthias Merian, a noted engraver and geographer.—As she showed a very great fondness for painting, she was instructed by Abraham Mignon; from whom she learned great neatness of handling and delicacy of colour. Her genius particularly led her to paint reptiles, flowers, and insects, which she designed after nature, and studied every object with a most curious and inquisitive observation; so that her works rose every day more and more into reputation. Frequently she painted her subjects in water colours on vellum, and finished an astonishing number of designs, as she was equally indefatigable in her work and in her inquiries into the curiosities of nature. She drew the flies and caterpillars in all the variety of changes and forms in which they successively appear from their quiescent state till they become butterflies; and also drew frogs, toads, serpents, ants, and spiders, after nature, with extraordinary exactness and truth. She even undertook a voyage to Surinam, to paint those insects and reptiles which were peculiar to that climate; and at her return to her own country published two volumes of engravings after her designs, which are well known to the curious. She died in 1717. Her daughter Dorothea Henrietta Graff, who painted in the same style, and had accompanied her mother to Surinam, published a third volume collected from the designs of Sibylla; which complete work has been always admired by the learned, as well as by the professors of painting.

MERIDA, a strong town of Spain, in Estremadura, built by the Romans before the birth of Christ. Here are some fine remains of antiquity, particularly a triumphal arch, but which is considerably decayed. It is seated in an extensive and fertile plain, 47 miles east of Elva, and 45 south by east of Alcantara. W. Long. 6. 4. N. Lat. 38. 42.

MERIDA, a town of North America, in New Spain, and capital of the province of Yucatan, where the bishop and the governor of the province reside. It is inhabited by Spaniards and native Americans; is 30 miles south of the sea, and 120 north-east of Campeachy. W. Long. 89. 25. N. Lat. 20. 15.

MERIDA, a town of South America, in the kingdom of New Granada, seated in a country abounding with all kinds of fruits, 130 miles north-east of Pampeluna. W. Long. 71. 0. N. Lat. 8. 30.

MERIDEN, or MIREDEN, a town of Warwickshire, 97 miles from London on the London road, near Coventry. It is pleasantly situated, though in a wet clayey situation, and is not ill built. The church stands on an elevated spot, and contains some good monuments. There is an inn here, about half way from

Malden | Merlon.

from St Clement's forest to Coventry, one of the finest in this part of England, being built like a nobleman's seat.

MERIDIAN, in *Geography*, a great circle supposed to be drawn through any part of the surface of the earth, and the two poles; and to which the sun is always perpendicular at noon. See GEOGRAPHY.

In astronomy, this circle is supposed to be in the heavens, and exactly perpendicular to the terrestrial one. See ASTRONOMY.

MERIDIANI, in antiquity, a name which the Romans gave to a kind of gladiators, who entered the arena about noon after the bestiarii (who fought in the morning against beasts) had finished. They were thus called from *meridies*, i. e. *noon*, the time when they exhibited their shows. The meridiani were a sort of artless combatants, who fought man with man, sword in hand. Hence Seneca takes occasion to observe, that the combats of the morning were full of humanity compared with those which followed.

MERIDIONAL DISTANCE, in *Navigation*, the same with departure, or easting and westing; being the difference of longitude between the meridian under which the ship now is, and any other meridian which she was under before.

MERIDIONAL parts, miles, or minutes, in *Navigation*, are the parts by which the meridians in a Mercator's chart do increase, as the parallels of latitude decrease.

MERIONETHSHIRE, a county of North Wales, is bounded on the north by Caernarvonshire and Denbighshire; on the east by Montgomeryshire; on the west by St George's channel, or the Irish sea; and on the south by Cardiganshire; extending 40 miles in length and 36 in breadth. It is divided into six hundreds; in which are four market towns, 37 parishes, about 6137 houses, and 30,924 inhabitants, in 1811. It lies in the diocese of Bangor, and sends one member to parliament. The air is very sharp in winter, on account of its many high barren mountains; and the soil is as bad as any in Wales, it being very rocky and mountainous. However, this county feeds large flocks of sheep, many goats, and large herds of horned cattle, which find pretty good pasture in the valleys. Besides these, among their other commodities may be reckoned Welch cotton, deer, fowl, fish, and especially herrings, which are often taken on this coast in great plenty. See MERIONETHSHIRE, SUPPLEMENT.

MERIT, signifies *desert*. This term is more particularly applied to signify the moral goodness of the actions of men, and the rewards to which those actions entitle them.

MERLIN, AMBROSE, a famous English poet and reputed prophet, flourished at the end of the 5th century. Many surprising and ridiculous things are related of him. Several English authors have represented him as the son of an incubus, and as transporting from Ireland to England the great stones which form Stonehenge on Salisbury plain. Extravagant prophecies and other works are also attributed to him, on which some authors have even written commentaries.

MERLIN. See FALCO, ORNITHOLOGY *Index*.

MERLON, in *Fortification*, is that part of a parapet which is terminated by two embrasures of a battery.

Merlucius, Mermaid.

MERLUCIUS, the HAKE. See GADUS, ICHTHYOLOGY *Index*.

MERMAID, or MERMAN, a sea-creature frequently talked of, supposed half human and half a fish.

However naturalists may doubt of the reality of *mermen* or *mermaids*, we have testimony enough to establish it; though, how far these testimonies may be authentic, we cannot take upon us to say. In the year 1187, as Lary informs us, such a monster was fished up in the county of Suffolk, and kept by the governor for six months. It bore so near a conformity with man, that nothing seemed wanting to it but speech. One day it took the opportunity of making its escape; and plunging into the sea, was never more heard of. *Hist. de Angleterre*, P. I. p. 403.

In the year 1430, after a huge tempest, which broke down the dikes in Holland, and made way for the sea into the meadows, &c. some girls of the town of Edam in West Friesland, going in a boat to milk their cows, perceived a mermaid embarrassed in the mud, with a very little water. They took it into their boat, and brought it with them to Edam, dressed it in woman's apparel, and taught it to spin. It fed like one of them, but could never be brought to offer at speech. Some time afterwards it was brought to Haerlem, where it lived for some years, though still showing an inclination to the water. Parival relates, that they had given it some notion of a Deity, and that it made its reverences very devoutly whenever it passed by a crucifix. *Delices de Hollande*.

In the year 1560, near the island of Manaar, on the western coast of the island of Ceylon, some fishermen brought up, at one draught of a net, seven mermen and mermaids; of which several Jesuits, and among the rest F. Hen. Henriques and Dimas Bosquez, physicians to the viceroy of Goa, were witnesses. The physician, who examined them with a great deal of care, and made dissection thereof, asserts, that all the parts both internal and external were found perfectly conformable to those of men. See the *Hist. de la campagnie de Jesus*, P. II. T. iv. N° 276. where the relation is given at length.

We have another account of a merman, seen near the great rock called *Diamond*, on the coast of Martinico. The persons who saw it, gave in a precise description of it before a notary. They affirmed that they saw it wipe its hand over its face, and even heard it blow its nose.

Another creature of the same species was caught in the Baltic in the year 1531, and sent as a present to Sigismund king of Poland, with whom it lived three days, and was seen by all the court. Another very young one was taken near Rocca de Sintra, as related by Damian Goes. The king of Portugal and the grand master of the order of St James, are said to have had a suit at law to determine which party these monsters belong to.

In Pontopidan's Natural History of Norway, also, we have accounts of mermaids; but not more remarkable or any way better attested than the above, to which we have given a place, merely to shew how far the folly and extravagance of credulity have been carried by weak minds.

MERNS, MEARNS, or KINCARDINESHIRE, a county of Scotland. See KINCARDINESHIRE.

MERODACH was an ancient king of Babylon, who was placed among the gods, and worshipped by the Babylonians. Jeremiah (chap. l. 2.), speaking of the ruin of Babylon, says, "Babylon is taken, Bel is confounded, Merodach is broken in pieces; her idols are confounded, her images are broken in pieces." We find certain kings of Babylon, in whose names that of Merodach is contained: for example, Evil-merodach and Merodach-baladan. Evil-merodach was the son of Nebuchadnezzar the Great, and had for his successor the wicked Belshazzar. Merodach-baladan, son of Baladan king of Babylon, having heard that Hezekiah had been cured miraculously (Isa. xxxix.), and that the sun had gone backwards to give him an assurance of his recovery, sent him presents, and made him compliments upon the recovery of his health. Ptolemy calls him *Mardoc-empadus;* and says, that he began to reign at Babylon 26 years after the beginning of the era of Nabonassar, that is, in the year of the world 2283.

MEROE, in *Ancient Geography*, an island of Ethiopia beyond Egypt, in the Nile; with a cognominal town, the metropolis of the Ethiopians.

The Jesuits have endeavoured to prove, that the province of Gojam in Abyssinia is the Meroë of the ancients; but this is strongly contested by Mr Bruce, who is of opinion, that it must be looked for somewhere between the source of the Nile and its union with the Atbara. The latter, he thinks, is very plainly the Astaboras of the ancients; and Pliny says, that this stream encloses the left side of Meroë as the Nile does the right, in which case we must suppose him looking southward from Alexandria, otherwise the words would not apply.

We are told by Diodorus Siculus, that Meroë had its name from a sister of Cambyses king of Persia, who died there in the expedition undertaken by that prince against the Ethiopians. His army perished with hunger and thirst in the deserts beyond Meroë, which could not have happened if they had reached Gojam, the latter being one of the most plentiful countries in the world. A further proof that Gojam cannot be the ancient Meroë is, that the latter was enclosed between the rivers Nile and Astaboras, while Gojam is almost entirely surrounded by the Nile. If the ancients were acquainted with Gojam, they must also have been acquainted with the fountains of the Nile, which we certainly know they were not. Pliny says that Meroë, the most considerable of all the islands of the Nile, was called *Astaboras*, from the name of its left channel, which cannot be supposed any other than the junction of the Nile and Atbara. He informs us moreover, that the sun was vertical twice in the year, viz. when proceeding northward he entered the 18th degree of Taurus, and when returning he came to the 14th degree of Leo; but this could never be the case with Gojam, which lies in about 10 degrees north latitude.

Again, the poet Lucan describes Meroë by two circumstances which cannot apply to any other than the peninsula of Atbara. One is, that the inhabitants were black; which was the case with the Gymnosophists and first inhabitants, and which has been the case with all the rest down to the Saracen conquest: but the inhabitants of Gojam, as well as the other Abyssinians, are fair, at least greatly different in complexion from the blacks; they are also long-haired, and nobody imagined that they ever had philosophers or science among them, which was eminently the case with the ancient inhabitants of Meroë. The other circumstance is, that the ebony tree grew in the island of Meroë, which at this day grows plentifully in the peninsula of Atbara, and part of the province of Kuara, but not in Gojam, where the tree could not subsist on account of the violent rains which take place during six months in the year. Mr Bruce mentions another circumstance quoted from the poet Lucan, which likewise tends to prove the identity of Meroë and Atbara; viz. that though there are many trees in it, they afford no shade. This our traveller found by experience, when returning from Abyssinia through Atbara. "The country (says he) is flat, and has very little water. The forests, though thick, afforded no sort of shade, the hunters for the sake of their sport, and the Arabs for destroying the flies, having set fire to all the dry grass and shrubs; which passing with great rapidity in the direction of the wind from east to west, though it had not time to destroy the trees, did yet wither, and occasion every leaf that was upon them to fall, unless in those spaces where villages had been, and where water was. In such spots a number of large spreading trees remained full of foliage; which, from their great height and being cleared of underwood, continued in full verdure, loaded with large, projecting, and exuberant branches. But even here the pleasure that their shade afforded was very temporary, so as to allow us no time for enjoyment. The sun, so near the zenith, changed his azimuth so rapidly, that every few minutes I was obliged to change the carpet on which I lay, round the trunk of the tree to which I had fled for shelter; and though I lay down to sleep perfectly screened by the trunk or branches, I was presently awakened by the violent rays of a scorching sun, the shade having passed beyond me. In all other places, though we had travelled constantly in a forest, we never met with a tree that could shade us for a moment, the fire having deprived them of all their leaves." The heat of Atbara is excessive, the thermometer having been observed at $119\frac{1}{2}°$: two of Mr Bruce's company died of thirst, or at least of the consequences of drinking after extreme thirst. The inhabitants live in the greatest misery, and are continually in danger from the neighbouring Arabs, who, by destroying and burning their corn, are able to reduce them to a starving condition. Notwithstanding all their disadvantages, however, they have a manufacture of coarse cotton towels, of a size just sufficient to go round the waist, which pass current as money throughout the whole country.

MEROM, in *Ancient Geography*. The waters of Merom, at which place Jabin and the other confederate kings met to fight (Joshua xi. 5.), are generally supposed by the learned to be the lake Semechon, which lies between the head of the river Jordan and the lake Gennesareth; since it is agreed on all hands, that the city Hazor, where Jabin reigned, was situated upon this lake. But others think that the waters of Merom or Merome were somewhere about the brook Kishon, since there is a place of that name mentioned in the account of the battle against Sisera (Judg. v. 21.). And it is more rational to think, that the confederate kings

advanced

advanced as far as the brook Kishon, and to a pass which led into the country, to hinder Joshua from penetrating it, or even to attack him in the country where he himself lay encamped, than to imagine that they waited for him in the midst of their own country; leaving all Galilee at his mercy, and the whole tract from the brook Kishon to the lake Semechon.

MEROPE, in *Fabulous History*, one of the Atlantides. She married Sisyphus the son of Æolus, and like her sisters was changed into a constellation after death. It is said that in the constellation of the Pleiades the star of Merope appears more dim and obscure than the rest, because she, as the poets observe, married a mortal, while her sisters married some of the gods or their descendants.

MEROPS, in *Fabulous History*, a king of the island of Cos, who married Clymene, one of the Oceanides. He was changed into an eagle, and placed among the constellations. Also a celebrated soothsayer of Percosus in Troas, who foretold the death of his sons Adrastus and Amphius, who were engaged in the Trojan war. They slighted their father's advice, and were killed by Diomedes.

MEROPS, a genus of birds belonging to the order of picæ. See ORNITHOLOGY *Index*.

MEROVINGIAN CHARACTER, derives its name from Meroüée, the first king of France of that race, which reigned 333 years, from Pharamond to Charles Martel. This race is said by some to have terminated in Childeric III. A. D. 751. There are many MSS. in the French libraries still extant in this character.

MEROZ, in *Ancient Geography*, a place in the neighbourhood of the brook Kishon, whose inhabitants refusing to come to the assistance of their brethren when they fought with Sisera, were put under an anathema (Judges v. 23.) "Curse ye Meroz, says the angel of the Lord; curse ye bitterly the inhabitants thereof: because," &c. Some have thought that Meroz is the same as Merus or Merom; and this F. Calmet thinks the most probable opinion in this matter. Others will have it, that Meroz was a mighty man, who dwelt near the Kishon, and not caring to come to the assistance of Barak and Deborah, was excommunicated by the angel of the Lord by the sound of 400 trumpets. The angel of the Lord, according to some, was Barak, the general of the Lord's army; but according to others he was the high priest for the time being, or a prophet.

MERSA, a town of Barbary, pleasantly situated about 11 miles from the city of Tunis, and two from Melcha the site of ancient Carthage. The bey has here two country houses, one of them very costly work, built by Hassan Bey surnamed the *Good*. From these are orange gardens reaching almost to the seashore; on the edge of which is a famous well of sweet water, esteemed the best and lightest in the kingdom. Close to this is a coffeehouse, whither numbers of people from the neighbouring places resort to drink coffee, and a glass of this natural luxury so peculiarly enjoyed in the eastern countries. In the middle of the court is a large mulberry tree, under the shade of which they sit and smoke and play at chess; inhaling the comfortable sea breeze that refreshes this delightful spot. The water is drawn up by a camel with the Persian wheel.

There are the remains of an ancient port, or cothon, (supposed to be an artificial one), built by the Carthaginians after Scipio had blocked up the old port, nothing but the turret or lighthouse being left.

MERS, or MERSE, a county of Scotland, called also *Berwickshire*. This last name it derives from the town of Berwick, which was the head of the shire before it fell into the hands of the English, and obtained the appellation of *Mers* or *March*, because it was one of the borders towards England. See BERWICK, *County of*.

MERSENNE, MARIN, in Latin *Mersennus*, a learned French author, born at Oysé, in the province of Maine, anno 1588. He studied at La Fleche at the same time with Des Cartes; with whom he contracted a strict friendship, which lasted till death. He afterwards went to Paris, and studied at the Sorbonne; and in 1611 entered himself among the Minims. He became well skilled in Hebrew, philosophy, and mathematics. He was of a tranquil, sincere, and engaging temper; and was universally esteemed by persons illustrious for their birth, their dignity, and their learning. He taught philosophy and divinity in the convent of Nevers, and at length became superior of the convent; but being willing to apply himself to study with more freedom, he resigned all the posts he enjoyed in his order, and travelled into Germany, Italy, and the Netherlands. He wrote a great number of excellent works; the principal of which are, 1. *Questiones celeberrimæ in Genesim*. 2. *Harmonicorum libri*. 3. *De sonorum natura, causis, et effectibus*. 4. *Cogitata physico-mathematica*. 5. *La verité des Sciences*. 6. *Les questions inouies*. He died at Paris in 1648. He had the reputation of being one of the best men of his age. No person was more curious in penetrating into the secrets of nature, and carrying all the arts and sciences to their utmost perfection. He was in a manner the centre of all the men of learning, by the mutual correspondence which he managed between them. He omitted no means to engage them to publish their works; and the world is obliged to him for several excellent discoveries, which, had it not been for him, would perhaps have been lost.

MERSEY, a river of England, which runs through the counties of Lancaster, York, and Chester, and empties itself into the Irish sea at Liverpool. By means of inland navigation, it has communication with the rivers Dee, Ribble, Ouse, Trent, Derwent, Severn, Humber, Thames, Avon, &c.; which navigation, including its windings, extends above 500 miles, in the counties of Lincoln, Nottingham, York, Lancaster, Westmoreland, Chester, Stafford, Warwick, Leicester, Oxford, Worcester, &c.

MERSEY Island, an island of Essex, at the mouth of the Coln, south of Colchester. It was seized by the Danes in the reign of King Alfred, for their winter quarters. It had eight parishes, now reduced to two, viz. East and West Mersey. There was formerly a blockhouse on the island.

MERULA, or *Blackbird*. See TURDUS, ORNITHOLOGY *Index*.

MERUS, in *Ancient Geography*, a mountain of the Hither India, hanging over the city Nyssa, built by Bacchus, and situated between the rivers Cophen and Indus. The name, denoting the *thigh*, gave rise to the fable of Bacchus being inserted into Jupiter's thigh, and being

being born twice; because in this mountain he and his army are said to have been preserved, when disease and pestilence raged in the plains below.

MESARAIC VESSELS, in the general sense, are the same with MESENTERIC.

In common use, mesaraic is more frequently applied to the veins, and mesenteric to the arteries, of the mesentery. See ANATOMY.

MESCHED, a considerable town of Persia, and in the province of Chorassan; fortified with several towers, and famous for the magnificent sepulchre of Iman Risa, of the family of Ali, to whom the Persians pay great devotion. It is seated on a mountain near this town, on which are fine turquoise stones; in E. Long. 59. 25. N. Lat. 37. 0.

MESEMBRYANTHEMUM, FIG-MARIGOLD, a genus of plants belonging to the icosandria class; and in the natural method ranking under the 13th order, *Succulentæ*. See BOTANY *Index*.

MESENTERIC, or MESARAIC, an epithet given to two arteries arising from the descending aorta, and proceeding to the mesentery. See MESENTERY.

MESENTERITIS, or *Inflammation of the* MESENTERY. See MEDICINE *Index*.

MESENTERY, MESENTERIUM, (formed of μεσος, *middle*, and εντερον, *intestine*), in anatomy, a fatty membranous body, thus called as being placed in the middle of the intestines, which it connects to one another. See ANATOMY, N° 94.

MESHES *of* NETS, the openings or interstices between the threads.

MESN, or MESNE, a term in law, signifying him who is lord of a manor, and so hath tenants holding of him; yet he himself holds of a superior lord.

The word is properly derived from *maisne*, *quasi minor natu*; because his tenure is derived from another, from whom he holds.

MESN also denotes a writ, which lieth where there is lord mesn and tenant; and the tenant is distrained for services due from the mesn to the superior lord.

This is in the nature of a writ of right; and in this case the tenant shall have judgment to be acquitted or indemnified by the mesne lord; and if he makes default therein, or does not appear originally to the tenant's writ, he shall be forejudged of his mesnalty, and the tenant shall hold immediately of the lord paramount himself.

MESOCHRI, were musicians among the ancients, who presided in concerts, and by beating a wooden desk regularly with their feet, directed the measure of the music. For the purpose of beating time, they wore wooden clogs, called by the ancients *crupezia*, which occasioned the sound to be better heard.

MESOCOLON, in *Anatomy*, that part of the mesentery, which, having reached the extremity of the ileum, contracts and changes its names. See ANATOMY, N° 94.

MESOLOGARITHMS, according to Kepler, are the logarithms of the co-sines and co-tangents; the former of which were called by Baron Napier *anti-logarithms*, and the latter *differentials*.

MESOPOTAMIA, the ancient name of the province of DIARBECK, in Turkey in Asia. It is situated between the rivers Euphrates and Tigris; having Assyria on the east, Armenia on the north, Syria on the west, and Arabia Deserta with Babylonia on the south. The Hebrews called it *Padan-aram*, (Gen. xxviii. 2. &c.) and *Aram Naharaim* (title of Psalm lx.) or Aram *of the two rivers*, because it was first peopled by Aram father of the Syrians, and is situated between the two rivers already mentioned. This country is much celebrated in Scripture, as being the first dwelling of men both before and after the deluge; and because it gave birth to Phaleg, Heber, Terah, Abraham, Nahor, Sarah, Rebekah, Rachel, Leah, and to the sons of Jacob. Babylon was in the ancient Mesopotamia, till, by vast labour and industry, the two rivers of the Tigris and Euphrates were united into one channel. The plains of Shinar were in the same country. Often they gave it the name of Mesopotamia (Deut. xxiii. 4. &c.) and sometimes that of Syria (Hosea xii. 12.). Balaam son of Beor was of Mesopotamia, Deut. xxiii. 4. Chushan-rishathaim king of Mesopotamia kept the Hebrews in subjection some time after the death of Joshua, Judg. iii. 8.

MESOPTERYGIUS, a term applied to such fishes as have only one back-fin, which is situated in the middle of the back.

MESPILUS, the MEDLAR, a genus of plants belonging to the icosandria class; and in the natural method ranking under the 36th order, *Pomaceæ*. See BOTANY *Index*.

MESS, in a military sense, implies a number of soldiers, who, by laying away a certain proportion of their pay towards provisions, mess together: six or eight is generally the number of each mess. Experience proves, that nothing contributes more to the health of a soldier, than a regular and well chosen diet, and his being obliged every day to boil the pot: it corrects drunkenness, and in a great measure prevents gaming, and thereby desertion.

MESSALINA, VALERIA, a daughter of Messala Barbatus. She married the emperor Claudius, and disgraced herself by her cruelties and incontinence. Her husband's palace was not the only seat of her lasciviousness, but she prostituted herself in the public streets, and few men there were at Rome who could not boast of having enjoyed the favours of the impure Messalina. Her extravagancies at last irritated her husband, who commanded her to appear and answer all the accusations which were brought against her: upon which she attempted to destroy herself; and when her courage failed, one of the tribunes who had been sent to her despatched her with his sword. It is in speaking of her debaucheries and lewdness that Juvenal says,

Et lassata viris, necdum satiata, recessit.

Her name has become a common appellation to denote a woman of shameless and inordinate lust.

MESSANA, in *Ancient Geography*, the first town of Sicily on crossing over from Italy, situated on the strait now called the *Faro*, (Italicus). Anciently called *Zancle*, according to Diodorus Siculus, from King Zanclus; or, according to others, from the Sicilian term *Zanclon*, denoting a sickle, alluding to the curvity of the coast; a name appropriated by the poets; and hence *Zanclæi*, the people, (Herodotus, Pausanias).

Messana
Messenia.

the other name *Messana* is from the *Messenii* of Peloponnesus, (Strabo). Thucydides ascribes its origin to Anaxilas the Messenian, tyrant of Rhegium, who received all comers, calling the town after the name of his country. The Greeks always call it *Messene;* the Romans *Messena* constantly, to distinguish it from *Messene* of Peloponnesus. Now MESSINA, lately ruined by earthquakes.

MESSENA, or MESSENE, an inland town, and the capital of Messenia, a country of Peloponnesus; erroneously placed by Ptolemy on the coast. It was built by Epaminondas, who recalled all the Messenian exiles, and gave the town the name of *Messene.* A place vying in point of strength and situation with Corinth, according to Strabo; and therefore Demetrius Phalereus advised Philip, father of Perseus, that if he wanted to have Peloponnesus in his power, he should make himself master of these two towns, as thus he would have the ox by both horns.

MESSENGERS, are certain officers chiefly employed under the direction of the secretaries of state, and always in readiness to be sent with all kinds of despatches foreign and domestic. By virtue of the secretaries warrants, they also take up persons for high treason, or other offences against the state. The prisoners they apprehend are usually kept at their own houses, for each of which they are allowed 6s. 8d. per day by the government: and when they are sent abroad, they have a stated allowance for their journey, viz. 30l. for going to Paris, Edinburgh, or Dublin; 25l. for going to Holland; and to other places in the same proportion; part of which money is advanced for the expence of their journey. Their standing salary is 45l. per annum; and their posts, if purchased, are esteemed worth 300l. But these sums have now probably been increased. The messengers wait 20 at a time, monthly, and are distributed as follows, viz. four at court, five at one secretary's office, five at another, two at the third for North Britain, three at the council office, and one at the lord chamberlain's of the household.

MESSENGERS, in Scotland. See LAW, Part III.

MESSENGERS of the Exchequer, are four officers who attend the exchequer, in the nature of pursuivants, and carry the lord treasurer's letters, precepts, &c.

MESSENGER of the Press, a person, who, by order of the court, searches printing-houses, booksellers shops, &c. in order to discover the printers or publishers of seditious books, pamphlets, &c.

MESSENIA, a country in the south of Peloponnesus, mostly maritime, situated between Elea to the west, and Laconia to the east. Anciently a part of Laconia under Menelaus, and called *Messene* by Homer; interpreted by the scholiast, *Messenæa Regio. Messenii*, the people, reduced to a state of slavery and subjection by the Spartans; *Messenius*, the epithet.

This country is famous in history, on account of the resistance made by the Messenians against the Spartans, and the exploits of their hero Aristomenes. The first hostilities commenced about the year 652 B. C. on what occasion is uncertain. Though the Messenians were inferior in the knowledge of the art of war to the Spartans; yet, by keeping for some time on the defensive, they improved so much, that in three years time they found themselves in a capacity of giving battle to their enemies in the open field; nor did they appear to be in any degree inferior either in courage or conduct: the war was therefore protracted, with various success, on both sides. At last, both consulted the oracle at Delphi; and received for answer, "that whoever should first dedicate 100 tripods in the temple of Jupiter at Ithome, a strong hold of the Messenians, should be masters of the country." The inhabitants of Messenia, on hearing this, having no money to make the tripods of brass, fell to cutting them out in wood; but before this could be accomplished, a Spartan having got into the city by stratagem, dedicated 100 little tripods of clay: which threw the Messenians into such despair, that they at last submitted to the Spartans.

Messenia.

The new subjects of Sparta were treated with the utmost barbarity by these cruel tyrants: so that a new war commenced under Aristomenes, a man of unconquerable valour, and enthusiastically fond of liberty. He perceived that the Argives and Arcadians, who were called the *allies* of the Lacedæmonians, adhered to them only through fear of their power; but that in reality they hated them, and wished to revenge the injuries they had done them. To these Aristomenes applied; and receiving an answer conformable to his wishes, he engaged his countrymen unanimously to take up arms. About a year after the revolt began, and before either party had received any auxiliaries, the Spartans and Messenians met at a village called *Deræ*, where an obstinate engagement ensued. Aristomenes was conceived to have performed more than mortal achievements: in gratitude therefore, respect being also had to his royal descent, his countrymen unanimously saluted him *king;* which title he modestly waved, alleging, that he took up arms to set them free, and not to make himself great; he consented, however, to accept the title of *general*, with a power of doing whatsoever he thought requisite for the service of the public. Knowing well the superstition of the age in which he lived, he resolved to intimidate the Spartans, by showing them what he was sure they would take for an ill omen. Disguising himself therefore, he went privately to the city, where, in the night, he hung up a shield on the wall of the temple of Minerva, with this inscription: *Aristomenes dedicates this, out of the spoils of the Spartans, to the goddess.* It was easily perceived that this war would be both long and bloody: the Lacedæmonians therefore sent deputies to Delphi, to inquire of the oracle concerning its event: the answer they received was, *That it behoved the Spartans to seek a leader from Athens.* The Athenians naturally envious of the Spartans, granted their request indeed, but in such a manner as manifested their spite; for they sent them for a general Tyrtæus, a schoolmaster and poet, lame of one foot, and who was suspected to be a little out of his wits. But here their skill failed them; for this captain, notwithstanding his despicable appearance, proved of great consequence to Sparta, teaching them how to use good, and how to bear up under ill fortune.

In the mean time, Aristomenes had drawn together a mighty army, the Eleans, Argives, Sicyonians, and Arcadians, having sent troops to his assistance; the Spartans in this, as in the former war, having no ally but Corinth. The Spartan kings, according to the custom

Messenia. custom of their city, no sooner took the field, than, notwithstanding their inferiority in number, they offered the enemy battle, which Aristomenes readily accepted. It was long, obstinate, and bloody; but in the end the Messenians were victorious, and the Lacedæmonians put to flight with a great slaughter. It is scarce to be conceived how much the Spartans were struck with this defeat: they grew weary of the war, dissatisfied with their kings, diffident of their own power, and in a word sunk into a state of general uneasiness and want of spirit. It was now that the Athenian general convinced them, that he was capable of fulfilling all the promises of the oracle; he encouraged them by his poems, directed them by his counsels, and recruited their broken armies with chosen men from among the Helotes. Aristomenes, on the other hand, acted with no less prudence and vigour. He thought it not enough to restore the reputation of the Messenians, if he did not also restore their wealth and power: he therefore taught them to act offensively against their enemies; and, entering the territories of Sparta, he took and plundered Pharæ, a considerable borough in Laconia, putting all such as made any resistance to the sword, carrying off at the same time an immense booty. This, however, was an injury which the Spartans could not brook with patience; they therefore sent immediately a body of forces to overtake the Messenians, which accordingly they did: but Aristomenes routed these pursuers, and continued to make a mighty slaughter of them, till such time as he was disabled by having a spear thrust in his side, which occasioned his being carried out of the battle. His cure, which took up some time, being finished, he resolved to carry the war even to the gates of Sparta; and to that purpose raised a very great army; but, whether he found his design impracticable, or was really diverted by some dream, he gave out, that Castor and Pollux, with their sister Helena, had appeared to him, and commanded him to desist. A short time after this retreat, going with a small party to make an incursion, and attempting to take prisoners some women who were celebrating religious rites near Egila, a village in Laconia, those zealous matrons fell upon him and his soldiers with such fury, that they put them to flight, and took him prisoner: however, he soon afterwards made his escape, and rejoined his forces. In the third year of the war, the Spartans with a great force entered Messenia, whither Aristocrates king of Arcadia was come, with a great body of troops to the assistance of his allies: Aristomenes therefore made no difficulty of fighting when the Spartans approached; but they entering privately into a negociation with Aristocrates, engaged him with bribes and promises to betray his confederates. When the battle began, the deceitful Arcadian represented to the forces under his command the mighty danger they were in, and the great difficulty there would be of retreating into their own country, in case the battle should be lost: he then pretended, that the sacrifices were ominous; and, having terrified his Arcadians into the disposition of mind fittest to serve his purpose, he not only drew them off from both wings, but, in his flight, forced through the Messenian ranks, and put them too in confusion. Aristomenes and his troops, however, drew themselves into close order, that they might defend themselves the best they could: and indeed they had need of all their valour and skill; for the Lacedæmonians, who expected this event, immediately attacked and surrounded them on all sides. Fortune was, on this occasion, too powerful either for the courage or the conduct of the Messenians; so that, notwithstanding their utmost efforts, most of their army were cut to pieces, and amongst them the chief of their nobility. Aristomenes, with the poor remains of his shattered forces, retired as well as he could; and, perceiving that it was now impossible to maintain the war against the Lacedæmonians upon equal terms, he exhorted his countrymen to fortify Mount Era, and to make the best dispositions possible for a long defence. He likewise placed garrisons in Pylus and Methone on the sea coasts; and to these three places he gathered all the inhabitants, leaving the rest of Messenia to the mercy of the Spartans. They, on the other hand, looked on the war as now in a manner finished; for which reason they divided the lands among their citizens, and caused them to be carefully cultivated, while they besieged Era. But Aristomenes quickly convinced them that the war was far from being over: he chose out of all the Messenians 300 men, with whom he ravaged all the adjacent country: carried off a prodigious booty; and, when Messenia could no longer supply the wants of his garrison, penetrated into Laconia, and bore away corn, wine, cattle, and whatever else was necessary to the subsistence of his countrymen shut up in Era: so that at last the Spartans were constrained to issue a proclamation, forbidding the cultivation, not only of the Messenian territory in their hands, but also of Laconia in its vicinity; whereby they distressed themselves more than their enemies, inducing at last a famine in Sparta itself, which brought with it its usual attendant, sedition. Here again all things had gone wrong, if the wisdom of the poet Tyrtæus had not supported the Spartan courage; nor was it without much difficulty that he influenced them to continue the blockade of Era, and to maintain a flying camp for the security of the country.

Aristomenes, in spite of all these precautions, committed terrible depredations with his small corps of 300 men. Amongst other places which he plundered, the city of Amyclæ was one; from whence he carried not only a great quantity of riches, but also many carriages laden with provisions. The kings of Sparta lying with their troops in its neighbourhood, as soon as they heard of this expedition, marched after Aristomenes with the utmost diligence; and, as the Messenians were encumbered with their booty, came up with them before they could reach Era. In this situation of things, Aristomenes, prompted rather by despair than prudence, disposed his troops in order of battle; and, notwithstanding they were so few, made a long and vigorous resistance against the whole Lacedæmonian army. At length, however, numbers prevailed: the greatest part of the Messenians were slain on the spot; and Aristomenes, with about 50 of his men who survived the slaughter, were taken prisoners; that chief having received so many wounds, that he was senseless when they carried him away. The Lacedæmonians expressed the loudest joy at the sight of this illustrious captive; who for so many years, by his single abilities, had

had enabled his exhausted country to defend itself against the whole force of Sparta. When he was recovered of his wounds, they decreed him and all his fellow prisoners to be thrown together into a deep cavern, which was the common punishment of the lowest kind of offenders. This judgment was executed with the utmost severity, excepting that Aristomenes had leave to put on his armour. Three days he continued in this dismal place, lying upon and covered over with dead bodies. The third day, he was almost famished through want of food, and almost poisoned with the stench of corrupted carcases, when he heard a fox gnawing a body near him. Upon this he uncovered his face, and perceiving the fox just by him, he with one hand seized one of its hind legs, and with the other defended his face, by catching hold of its jaw when it attempted to bite him. Following as well as he could his struggling guide, the fox at last thrust his head into a little hole; and Aristomenes then letting go his leg, he soon forced his way through and opened a passage to the welcome rays of light, from which the noble Messenian had been so long debarred. Feeble as he was, Aristomenes wrought himself an outlet with his nails; and travelling by night with all the expedition he could, at length arrived safe at Era, to the great joy and amazement of his countrymen. When this news was first blazed abroad, the Spartans would have had it pass for a fiction; but Aristomenes soon put the truth of it out of doubt, by falling on the posts of the Corinthians, who, as allies of the Spartans, had a considerable body of troops before Era. Most of their officers, with a multitude of private men, he slew; pillaged their camp; and in short, did so much mischief, that the Spartans under the pretence of an approaching festival, agreed to a cessation of arms for 40 days, that they might have time to bury their dead. On this occasion, Aristomenes for the second time celebrated the *hecatomphonia*, or the sacrifice appointed for those who had killed 100 of the enemy with their own hands. He had performed the same before and after his second battle: and he lived to do it a third time: which must appear wonderful to the reader, when he is informed, that notwithstanding this truce, certain Cretan archers in the service of the Spartans seized Aristomenes as he was walking without the walls, and carried him away a prisoner. There were nine of them in all: two of them immediately flew with the news to Sparta, and seven remained to guard their prize, whom they bound, and conducted to a lone cottage inhabited only by a widow and her daughter. It so fell out that the young woman dreamt the night before that she saw a lion without claws, bound, and dragged along by wolves; and that she having loosed his bonds, and given him claws, he immediately tore the wolves to pieces. As soon as Aristomenes came into the cottage, and her mother, who knew him, had told her who he was, she instantly concluded that her dream was fulfilled; and therefore plied the Cretans with drink, and when they were asleep, took a poniard from one of them, cut the thongs with which Aristomenes was bound, and then put it into his hands. He presently verified her vision, by putting all his guards to death; and then carried her and her mother to Era, where, as a reward for her service, he married the young woman to his son Gorgus, then about 18 years of age.

When Era had held out near eleven years, it fell into the hands of Sparta by an accident: the servant of one Empiramus, a Spartan commander, driving his master's cattle to drink at the river Neda, met frequently with the wife of a Messenian whom he engaged in an amour. This woman gave him notice, that her husband's house was without the wall; so that he could come to it without danger, when the good man was abroad; and she likewise gave him intelligence when her husband was upon duty in the garrison. The Spartan failed not to come at the time appointed; but they had not been long in bed before the husband returned, which put the house into great confusion; the woman, however, secured her gallant; and then let in her husband, whom she received in appearance with great joy, inquiring again and again by what excess of good fortune she was blessed with his return. The innocent Messenian told her, that Aristomenes being detained in his bed by a wound, the soldiers knowing that he could not walk the rounds, had a grant to retire to their houses, to avoid the inclemency of the season. The Spartan no sooner heard this, than he crept softly out of doors, and hastened away to carry the news to his master. It so happened, that the kings were at this time absent from the camp, and Empiramus had the chief command of the army. As soon as he received this information, he ordered his army to begin its march, though it rained excessively, and there was no moon light. The fellow guided them to the ford, and managed matters so well that they seized all the Messenian posts: yet, after all, they were afraid to engage; darkness, and high wind, heavy rain, together with the dread of Aristomenes, keeping them quiet in the places they had seized. As soon as it was light the attack began; and Era had been quickly taken, if only the men had defended it; but the women fought with such fury, and by their mingling in the fray, brought such an accessien of numbers, as made the event doubtful. Three days and two nights this desperate engagement lasted: at last, all hopes of preserving the city being lost, Aristomenes drew off his wearied troops. Early in the fourth morning, he disposed the women and children in the centre, the Messenian youth in the front and rear, the less able men in the main body: himself commanded the van; the rear-guard was brought up by Gorgus and Manticlus, the former the son of Aristomenes, the latter of Theocles, a Messenian of great merit, who fell with much glory in this attack, fighting valiantly in the cause of his country. When all things were ready, Aristomenes caused the last barrier to be thrown open; and, brandishing his spear, marched directly towards the Spartan troops, in order to force a passage. Empiramus, perceiving his intent, ordered his men to open to the right and left, and fairly gave them a passage; so that Aristomenes marched off in triumph, as it were, to Arcadia.

The Arcadians, when they heard that Era was taken, were very desirous of succouring their old confederates in this deep distress: they therefore entreated their king Aristocrates to lead them into Messenia.

Messenia, Messiah.

Messenia. But he, corrupted by the Lacedæmonians, persuaded them that it was too late; that the Messenians were all cut off; and that such a step would only expose them to the fury of the conquerors. When the thing appeared to be otherwise, and it was known that Aristomenes was on the frontiers of Arcadia, they went in crowds to carry him provisions, and to testify their readiness to afford him and those under his command all the assistance in their power. Aristomenes desired to be heard before a general assembly; which being accordingly convoked, he there opened one of the boldest and best laid schemes recorded in history; he said, that he had yet 500 undaunted soldiers, who, at his command, would undertake any thing; that it was very probable most of the Spartans were employed in pillaging Era, and that therefore he determined to march and surprise Sparta; which appeared so sensible, that all the assembly loudly commended his great capacity and unshaken courage. Aristocrates, however, took care to betray him; having, by various pretences, retarded the execution of the project. The Arcadians, who began to suspect him, waited for and surprised the messengers as they came back. They took the letters from them, and read them openly in the assembly. The purport of them was, that they acknowledged his great kindness both now and in the battle; and promised, that the Lacedæmonians would be grateful. As soon as the letters were read, the Arcadians fell to stoning their king, frequently calling upon the Messenians to assist them; which, however, they did not, waiting for Aristomenes's order; who, far from triumphing in this spectacle, stood still, with his eyes fixed on the ground, which he wet with his tears, his soul pierced with sorrow to see a crowned head so shamefully and so deservedly put to death. The Arcadians afterwards erected a monument over him, with an inscription to perpetuate his infamy. As for the Messenians under the command of Gorgus and Manticlus, they passed over into Sicily; where they founded the city of Messene, one of the most famous in the island. Aristomenes remained, however, in Greece; where he married all his daughters, except the youngest, to persons of great rank. A prince of Rhodes, inquiring of the oracle at Delphi whom he should espouse, that his subjects might be happy under his posterity, was directed to marry the daughter of the most worthy of the Greeks; which answer was immediately understood to point at the virgin daughter of Aristomenes. Her therefore he demanded, and received; Aristomenes accompanying him back to his dominions, where he formed a scheme of uniting the Lydians and Medes against the Spartans, resolving with this view to go into Media, and to the court of Sardis; but while he meditated those great things, death surprised him, and thereby freed Lacedæmon from the most formidable enemy she ever had.

MESSIAH, a word signifying one *anointed*, or installed into an office by unction. It was usual among the Jews to anoint kings, high priests, and sometimes prophets, at the designation or installment of them, to signify emblematically the mental qualifications necessary for discharging those offices. Saul, David, Solomon, and Joash, kings of Judah, received the royal unction. Aaron and his sons received the sacerdotal, and Elisha the disciple of Elijah received the prophetic unction.—The name MESSIAH, *Anointed*, or *Christ*, (Χριστος), was given to the kings and high priests of the Jews. The patriarchs and prophets are also called by the name of *Messiahs*, or the *Lord's anointed*. See 1 Sam. xii. 3, 5. 1 Chron. xvi. 22. Ps. cv. 15.

Messiah.

But this name MESSIAH was principally and by way of eminence given by the Jews to their expected great deliverer, whose coming they still vainly wait; and is a name the Christians apply to JESUS *Christ*, in whom the prophecies relating to the Messiah were accomplished. The sum of these prophecies is, That there should be a glorious person named *Messiah*, descended from Abraham, Isaac, and Jacob, who should be born at Bethlehem, of a virgin of the family of David, then in its decline, before the Jews ceased to be a people, while the second temple was standing, and about 500 years after Ezra's time; who, though appearing in mean circumstances, should be introduced by a remarkable forerunner, whose business it should be to awaken the attention and expectation of the people. That this illustrious person called *Messiah* should himself be eminent for the piety, wisdom, and benevolence of his character, and the miraculous works he should perform: yet that, notwithstanding all this, he should be rejected and put to death by the Jews; but should afterwards be raised from the dead, and exalted to a glorious throne, on which he should through all generations continue to rule, at the same time making intercession for sinners. That great calamities should for the present be brought on the Jews for rejecting him; whereas the kingdom of God should by his means be erected among the Gentiles, and disperse itself even unto the ends of the earth; wherever it came, destroying idolatry, and establishing true religion and righteousness. In a word, That this glorious person should be regarded by all who believed in him as a divine teacher, an atoning sacrifice, and a royal governor; by means of whom God would make a covenant with his people, very different from that made with Israel of old; in consequence of which they should be restored to, and established in, the divine favour, and fixed in a state of perpetual happiness. See *JESUS Christ*, and CHRISTIANITY.

The Jews, as was already observed, still wait for the coming of the *Messiah*, being impressed with the notion of a temporal *Messiah*, who is to be a mighty conqueror, and to subdue all the world. Most of the modern rabbins, according to Buxtorf, believe that the *Messiah* is already come, but that he keeps himself concealed, and will not manifest himself because of the sins of the Jews. Some of the Jews, however, in order to reconcile those prophecies that seem to contradict each other as to the character and condition of the *Messiah*, have had recourse to the hypothesis of two *Messiahs*, who are yet to succeed each other; one in a state of humiliation and suffering; the other of glory, splendor, and power. The first, they say, is to proceed from the tribe of Ephraim, who is to fight against Gog, and to be slain by Annillus, Zech. xii. 10. The second is to be of the tribe of Judah, and

Messia. Messina.

and lineage of David, who is to conquer and kill Annillus, and restore the kingdom of Israel, reigning over it in the highest glory and felicity.

Jesus Christ asserts himself the *Messiah*. In St John iv. 25. the Samaritan woman says to Jesus, *I know that when* Messiah *comes, who is called the* Christ, *he will tell us all things. Jesus answered her, I that speak to thee am he.*

There are several impostors, who have endeavoured to pass for *Messiahs*, as Christ himself predicted. J. Lent, a Dutchman, has written a history *De Pseudomessiis* " Of false Messiahs." The first he mentions was one Barcochab, who appeared under the empire of Adrian. The last was Rabbi Mordecai, who began to be talked of in 1682. A little before him, viz. in 1666, appeared Sabbethai Sebi, who was taken by the Turks, and turned Mahometan.

MESSINA, an ancient, large, handsome, and strong city of Sicily, and in the Val di Demona, with a citadel, several forts, a fine spacious harbour, and an archbishop's see. It is seated on the sea side, 110 miles east of Palermo, 260 south by east of Rome, and 180 south-east of Naples. E. Long. 15. 50. N. Lat. 38. 10. The public buildings and the monasteries were numerous and magnificent, and it contained about 60,000 inhabitants; the harbour is one of the safest in the Mediterranean, and extremely deep; the viceroy of Sicily resides here six months in the year; and it was a place of great trade in silk, oil, fruit, corn, and excellent wine, especially since it was declared a free port. This city in the beginning of the year 1783 suffered most dreadfully by the earthquakes which shook great part of Calabria and Sicily to their foundations, overturned many rich and populous towns, and buried thousands in their ruins: (see CALABRIA, and EARTHQUAKE, GEOLOGY *Index*).—The following account of Messina, as it stood before the above period, is extracted from Mr *Swinburne's Travels in Sicily*.

A large chain of mountains presses upon the shore, and part of the city stands upon elevated ground. The mountains are many of them nobly wooded; the hills before them finely chequered with groves and fields. As the town runs in a sweep along the edge of a declivity, every building of consequence is seen to advantage, while the less noble parts are hidden by the Palazzata. This is a regular ornamental range of lofty houses, with 19 gates, answering to as many streets: it follows the semicircular bend of the port for one mile and five poles, and would have been the handsomest line of buildings in Europe had the design been completed; but a considerable part of the extent is not finished, except merely in the front wall, and that seems to be in a very ruinous condition. Philibert Emmanuel of Savoy, viceroy of Sicily, in 1622, began this princely work. Before it is a broad quay, decorated with statues and fountains; ships of any burden can moor close to the parapet in great depth of water. At the west extremity is a small fort and a gate; the other end is closed by the governor's house and the citadel, a modern pentagonal fortress, built on the point where the isthmus or *braccio di San Raniero* issues from the main land. On this slip of low ground, which with the Palazzata forms the circular harbour of Messina, is placed the lighthouse (*lazaretto*), and on the point the old castle of St Salvatore. The circumference of the port is four miles: it probably owes its formation to an earthquake, which opened an immense chasm, and then filled it with water. Near the lighthouse is a kind of whirlpool in the sea, shown as the Charybdis of the ancients.

The inner part of Messina is dirty, though it contains a considerable number of neat churches and large substantial dwellings. The cathedral is Gothic, enriched with Saracenic mosaics on the altars and shrines; the front of the high altar is particularly splendid: Gagini has embellished the pulpit and some tombs with excellent specimens of his art.—In the treasury of this church is preserved the palladium of Messina, a letter from the Virgin Mary to its citizens (A). This is the title upon which the Messinese build their pretensions

(A) The story is as follows: After St Paul had made some stay at Messina (a circumstance of his travels unnoticed by St Luke), the Messinese prevailed upon him to return to Jerusalem with an embassy of four persons sent by the city to the Virgin Mary. Their excellencies were graciously received by her, and brought back a letter written with her own hand in the Hebrew tongue, which St Paul translated into Greek. By the irruption of the Saracens this invaluable treasure was lost, and utterly forgotten till the year 1467, when Constantine Lascaris, a refugee Greek, found a copy of it, and turning it into Latin, made it known to the citizens, and then to all the Catholic world. Its authenticity is now so well established at Messina, that Regna the historian candidly acknowledges, that whoever was to confess even a doubt on the subject in that city would be treated as an infidel.

This curious epistle is conceived in these terms:—Maria Virgo, Joachim filia, Dei humillima Christi Jesu crucifixi mater, ex tribu Judæ, stirpe David, Messanensibus omnibus salutem, et Dei Patris Omnipotentis benedictionem. Vos omnes fide magna legatos ac nuncios per publicum documentum ad nos misisse constat. Filium nostrum Dei genitum Deum et hominem esse fatemini, et in cœlum post suam resurrectionem ascendisse, Pauli apostoli electi prædicatione mediante viam veritatis agnoscentes. Ob quod vos et ipsam civitatem benedicimus, cujus perpetuam protectricem nos esse volumus. Anno filii nostri XLII. Indict. I. III. Nonas Junii, luna XXVII. feria V. ex Hyerosolymis.

Thus translated:—" The Virgin Mary, daughter of Joachim, most humble mother of God, Jesus Christ crucified, of the tribe of Juda and the family of David, health and the blessing of God the Father Almighty to all the people of Messina. Out of the abundance of your faith, you have, in consequence of a public deliberation, sent a deputation to me; and since you acknowledge that my son is both God and man, and that he ascended into heaven after his resurrection, as you have learned from the preaching of St Paul the apostle, I

Messina.

pretensions to pre-eminence over the whole island, nay over the whole world; to its virtues and patronage they attribute every piece of good fortune, and to their own unworthiness all sinister events that have befallen them. The authenticity of this epistle has been seriously impugned, and of course vigorously defended by many Sicilian divines and disputators.

There is another church in this city that deserves particular notice, not so much on account of its architecture or ornaments, as for its being the last refuge of the Greek liturgy, which was once the predominant service of the island, but gradually abolished by different conquerors. It is dedicated to the Virgin Mary de Grapheo, or of the *Letter*, which denomination may perhaps have furnished Lascaris with the idea of his letter. It is known at present by the name of *la Cattolica*. According to the Greek canons, the entrance of monastic churches was reciprocally forbidden to each sex, and the cathedrals were the only places of worship where a daily sacrifice was offered up by the bishop and clergy, and where both men and women were present at the same time, but in different parts of the church. From this general admittance the building acquired the title of *Catholic* or *universal*.

Messina is all paved with lava, cut into large flags of two feet square: a material which the vicinity of lavas renders it easy to procure, and which being very hard resists friction better than any other.

During a series of ages, notwithstanding the various revolutions and calamities to which it has been exposed, this city has still maintained its original situation; while most other cities have shifted their ground more or less from the place where they were first founded. But its situation enjoys advantages which have still tempted such of its inhabitants as escaped from the ravages of war and the desolation of earthquakes to prefer it to every other spot, however delightful or secure. It is of very ancient origin; it has been under many different races of monarchs, and its name has been repeatedly changed: It has been at different times called *Zancle*, *Mamertina*, *Messana*. Its first name *Zancle*, which in the old language of Sicily meant "a sickle;" alluding, as some authors suppose, to the form of the port; or, according to others, to the fertility of the country. Allured by the advantages of its situation, the Cumæans, a commercial and enterprising people, invaded the island and drove the Siculi from this settlement; they were in their turn overpowered by a band of Samian adventurers, who made way for a colony of citizens of Messene, and under these masters it changed its name to *Messana*. Their government was of short duration; for in the 289th year before Christ it was destroyed by the Mamertines, a warlike unprincipled nation inhabiting the south part of Bruttium. These soldiers being received into Messana on their return to Italy from Syracuse, where they had served as mercenaries in the army of Agathocles, took an opportunity of massacring the inhabitants and usurping their possessions. The city was now called *Mamertina*; and, in order to support themselves against the resentment of the Sicilian powers, the Mamertines implored the protection of the Romans, who, eager to extend their dominion beyond the limits of Italy, and jealous of the growing power of Carthage, made no scruple to succour these assassins with a consular army. This step brought on the first Punic war. The Mamertines reaped no other fruit from the alliance but a more honourable degree of slavery; for such was the real nature of their connexion with Rome, whatever name it might be disguised under.

Messina was, however, always distinguished by particular attentions and favours from the senate; and, excepting a short period during the wars of the triumvirate, appears to have tasted all the sweets of Roman prosperity, without partaking of the bitter draughts of adversity. Its fate, in the ruin of the empire, was similar to that of the rest of Sicily. In 829 Messina fell into the hands of the Saracens, but obtained very honourable terms of capitulation; for half the city was left to the Christians, where they were to be governed by their own laws, and profess their own religion undisturbed. In the other resided the bey of one of the five provinces into which the Arabian conquerors had divided the island. Notwithstanding this indulgence, Messina was the first to cast off the yoke in 1037, when George Maniaces landed an army of Greeks and Normans on the shore of the Faro. It afterwards held out against the whole Mussulman force, till the feeble state of a distracted empire shut out all hopes of assistance from Constantinople. This unfortunate city then opened its gates to the army of the caliph, and felt very severely the weight of his resentment, but it did not long groan under the yoke; for in less than 20 years Roger the Norman took it by surprise, and delivered it from Mahometan oppression. During the crusade our Richard Cœur de Lion and Philip Augustus king of France wintered here in their way to Palestine; a sojourn marked by continual quarrels, conflagration, and bloodshed. The Messinese were particularly tardy in entering into the national conspiracy of 1282, but afterwards exceeded the rest of the insurgents in deeds of cruelty: This, and the importance of their situation, singled them out for the first objects of Charles's vengeance. He invested their city very closely, and declared so openly his determination to refuse all terms whatever to the besieged, that they saw no hopes of safety but in an obstinate defence. Their courage, perseverance, and sufferings, were excessive; at length their strength and resources began to fail rapidly, and every circumstance seemed to denounce their speedy destruction, when Roger Lauria appeared off the harbour with the Arragonian fleet, forced the king to retire with precipitation across the

I give my blessing to you and all your city, and agree to become your protectress. In the 42d year of my Son, the 1st of the indiction, the 3d day of June, and the 27th of the moon, at Jerusalem."

Not to dwell upon the astronomical blunders in these dates, let it suffice to observe, that Lascaris was not aware that Denis the Little, a Syrian monk in the 6th century, was the first who made use of the era that commences at our Saviour's birth.

the straits, and in his sight defeated and destroyed his naval armament. Robert, grandson of Charles I. also made a fruitless attack; but in the disturbed reign of Frederic III. Messina was delivered up to Louis king of Naples and his consort Queen Joan, who entered it in triumph. In a few years it returned to its former possessors. The year 1672 was remarkable for the revolt of the Messinese.—They threw off the Spanish yoke, and swore allegiance to Louis XIV. king of France. They were for some time vigorously assisted by the French; but before the Spaniards had gained the least advantage to excite any hopes of recovering so valuable a possession, Louis found himself necessitated from motives of political interest to desert his new subjects, and leave them to the mercy of their old incensed masters. The horror of being thus abandoned, and the chastisement inflicted by Spain, broke the fierce spirit of the Messinese; they were still stunned with the remembrance and effects of this blow, when the plague in 1743 was introduced from the Levant, and swept away more than half the inhabitants. From this chain of calamities, the opulence, trade, and population of Messina, have been gradually sinking; and unless very favourable circumstances happen, will every year fall lower. The number of its inhabitants does not now exceed 30,000.

The following particulars are added from M. Houel, who visited this city since the late earthquakes, which completed its destruction.

On the front of the cathedral there is a square, which, though not regular, is far from being mean. This was not the largest square in Messina before its overthrow; but it was the most elegant, the most splendidly adorned, and the best frequented. There stands in this square an equestrian statue of Charles II. of Spain, in bronze, which has been spared by the earthquake. It stands on a marble pedestal, in the middle of the square. Opposite to this statue is an elegant marble fountain, ornamented with a variety of figures, representing men and other animals, all of them spouting out water in great abundance; which used, in summer, to spread an agreeable and refreshing coolness over the square, that induced company to assemble here. Seven streets terminated here. The cathedral forms a part of the square. It is dedicated to the blessed Virgin; the occasion of which has been already mentioned.

There is an anniversary feast celebrated in Messina, which is called *the feast of the Letter*. A lock of the Virgin's hair, which she sent to the Messenians at the same time with the letter, is carried through the city in procession in a crystal vessel. She made also a present of her picture to the Messenian deputies. It is placed over the tabernacle. None but the canons of the cathedral are permitted to touch, or take up on their shoulders, the silver shrine in which the crystal vessel with the Virgin's hair is deposited. Eight of those canons, with mitres on their heads, bear this shrine in the procession. The canopy suspended over it is supported by six senators in their robes. The picture and the hair are shown to strangers. This procession, and the other religious ceremonies of this festival, are followed by horse races. The spirits of the people being already elevated by their religious exercises, they engage with amazing eagerness in these and the other diversions with which they are accompanied: a tumultuous joy reigns over the city; and the evening concludes with illuminations and fireworks. The ships in the harbour pay the citizens the compliment of entertaining them with a discharge of their guns on the occasion.

Through a square called the *Square of the Great Hospital*, runs a large and impetuous torrent, the *Porto delle Legni*. It is precipitated from those lofty mountains which overlook this city on the south side. The channel which it has cut out for itself is at times entirely full. It would, on such occasions, overflow the square and other parts of the city, were it not confined by walls which have been built on both sides to prevent such accidents.—Another stream of a similar origin, called the *Torrent of La Bocetta*, runs through another part of the city, it is also confined within walls to prevent it from overflowing.

The *Square of St John of Malta* is one of the largest in Messina. In the middle of this square is a fine marble fountain, ornamented with a variety of sculptured figures and jets d'eau. Beside the fountain there used to stand a large reservoir for horses to drink out of.

In the time of the annual festivals, there used to be exhibited on the water of the reservoir a galley, or rather a fictitious representation of a galley, with galley-slaves, soldiers, officers, and a commander on board, all in arms, and the galley properly equipped as a ship of war. This galley was decorated with great art; and by night the masts, and every other suitable part, were hung with lamps, which illuminated it in a very splendid manner. Every thing around was so artificially disposed, that when the fire-works were played off, the spectator was led to think, though he perceived only one galley, that the noise which he heard was produced by a naval combat; and that the other ships were concealed from his view by the smoke occasioned by the guns and fireworks. This, when properly conducted, was a noble spectacle. The senate repaired thither from the cathedral, attended with a guard and a numerous company. In one carriage sat six senators, the governor of the city, and sometimes the archbishop. It was exceedingly large and drawn by six white horses very richly harnessed. Other carriages followed, with the train who attended the governor and the senators.

Almost all festivals owe their origin to some extraordinary event, or some singular story either true or false. It is said, that when the splendor with which the feast of the *Assumption de la Bara* was celebrated at Messina, first began to attract foreigners to the city, on that occasion such crowds repaired thither as to alarm the inhabitants with the fears of a famine: But one year, when the number of strangers was greater than usual at the time of this festival, the magistrates were very much at a loss how to supply them with provisions; and at length, every other resource failing, no hopes of relief remained but from the kindness of the Blessed Virgin. Fervent prayers were addressed to their patroness: and next morning by day-break three brigantines appeared entering the harbour with full sails. They proved to be loaded with corn. It was eagerly purchased: and the people of the city hasted to appease their hunger. But when they came after

Messina. refreshing themselves to pay the corn merchants their money, neither ships nor merchants could be found. After their first emotions of surprise had subsided, they naturally concluded that such a seasonable supply must undoubtedly be a present from the Virgin, who, being pleased with the zeal of her Messenian votaries, and desirous to prevent the concourse of strangers who attended the festival from diminishing, had interposed in this miraculous manner to save them from the distresses of famine. A new festival was celebrated in gratitude to their generous benefactress. Three small vessels of silver were made, and dedicated to the Virgin in memory of the event; and these are at present used as lamps in the cathedral. The senate likewise decreed, that the clergy should pay annually a small tax, to be laid out in constructing a small galley to swim on the fountain, and in defraying the expences of the fireworks. The profits of the clergy are so considerable on the occasion of the festival, that they may be supposed to pay the tax with great cheerfulness.

In Messina, as in the other cities of Sicily, the women wrap themselves in a large black mantle above the rest of their dress. The stuffs are richer or plainer according to rank and circumstances. People who are not rich enough to have fine clothes of their own, hire them at so much an hour. There are women who make a livelihood by lending out their clothes. The mantle covers the wearer from head to foot.—It reduces the old and the young, the ill-shaped and the handsome, pretty much to an equality in point of appearance. This must naturally appear very unfavourable to the influence of beauty. But yet, on proper occasions, at church or in a public walk, the ladies of Messina find means to open and adjust the mantle so as to display all their beauties of face and shape, and to attract the affections of lovers, perhaps more powerfully than if their dress were suited to display their charms in a more ostentatious manner.

Between Messina and the tower of Faro there stands a small church called the *Madona of the Grotto*. It was anciently a temple of a round structure, and ornamented with columns like the temple of the sun at Rome. Modern columns now supply the place that was occupied by the ancient. There are large niches in the rock adjoining to the temple, which are thought to be of equal antiquity. These contain no sculptured figures; but in Pagan times they might possibly contain some.

Messina being situated between Mount Ætna and the gulf of Charybdis, and being likewise at no great distance from the volcanoes of Lipari and Stromboli, must have been in all ages liable to suffer by earthquakes. Such terrible events, however, appear to have been more unfrequent in ancient than in modern times, and have actually alarmed the present age oftener than any other. In the year 1693 a fourth part of the cities of Sicily was destroyed by an earthquake. Messina merely felt the shock; all its buildings, however, suffered. In the year 1742 it suffered another equally violent. A plague which followed in 1743 retarded the repairs necessary after the earthquake. In the year 1780 this city continued, for more than six months, to suffer from new earthquakes.

Were the state of the elements, previous to these dreadful events, carefully examined, it might perhaps be found to undergo certain changes which might be considered as prognosticating them. Messina.

The autumn of the year 1782 was unusually cold and rainy. Fahrenheit's thermometer was often as low as 56 degrees. The succeeding winter was dry; and the mercury never fell under 25 degrees: And, what is uncommon in that season, storms were now and then observed to arise from the west. The pilots in the channel observed that the tides no longer rose at the usual periods, and the gulf of Charybdis raged with extraordinary fury.

On the 5th of February 1783, the air was heavy and calm; the sky obscured with thick clouds, and the atmosphere seemingly all in a flame. About half after twelve at noon, the earth began to shake with a dreadful noise. The shocks continually increased, and became at length so violent as to open the ground, and to overturn in two or three minutes a considerable part of the buildings.

A long white cloud appeared to the north-west; and soon after another, very dark, in the same quarter of the heavens. The latter in a moment spread over the whole horizon, and deluged the city with rain and hail, accompanied with dreadful claps of thunder. The inhabitants fled in the utmost terror to the fields and the ships in the harbour.

From mid-day till five in the afternoon the earthquake continued almost without interruption. The shocks then became somewhat less frequent. The cries of the dying; the shrieks of those who were half buried under the ruins; the wild terror with which others, who were still able, attempted to make their escape; the despair of fathers, mothers, and husbands, bereft of those who were dearest to them; then formed altogether a scene of horror, such as can but seldom occur in the history of the calamities of the human race. Amid that awful scene, instances of the most heroic courage and the most generous affection were displayed. Mothers, regardless of their own safety, rushed into every danger to snatch their children from death. Conjugal and filial affection prompted deeds not less desperate and heroic. But no sooner did the earthquake cease, than the poor wretches who had escaped began to feel the influence of very different passions. When they returned to visit the ruins, to seek out the situation of their fallen dwellings, to inquire into the fate of their families, to procure food and collect some remains of their former fortunes—such as found their circumstances the most wretched became suddenly animated with rage, which nothing but wild despair could inspire. The distinction of ranks, and the order of society were disregarded, and property eagerly violated. Murder, rapine, and lawless robbery, reigned among the smoking ruins.

About one in the morning another shock of the earthquake was felt, which overturned most of the houses that were still standing. Most of those whom want, or avarice, or humanity, still detained among the ruins, now shared the same fate with their friends whom the former shocks had buried under them.

The succeeding day scarce alleviated the distress of this dismal night: the few wretches who still survived found themselves destitute of every necessary. At length order was in some degree re-established; and in two

two days after every person was supplied at least with some small portion of the necessaries for subsistence.

None yet thought of returning to take up their abode among the ruins. The common people fixed their residence on the plain of Porto Salvo, near the town of Salleo. The nobles, magistrates, and merchants, took up their abode on another plain, on the other part of the stream Porto de Legno; the soldiers at Terra Nuova.

Some violent shocks which were again felt on the 7th of February and the 28th of March completed the destruction of the city. The corn magazines, however, escaped without damage: and the public ovens and the aqueducts were but little injured. From these facts it may perhaps be inferred, that had not the houses of Messina been, in general, hastily built at the first, and afterwards carelessly repaired, fewer of them would have been overthrown by the earthquake.

The neighbouring villages having suffered but little, were the first to relieve the remaining inhabitants of Messina in their distress. Maltese gallies for some days supplied necessaries to the poor and the sick with a generosity which merits the highest praise. They brought surgeons and whatever was needful for the cure of the wounded. The supplies sent by the king of France were refused, for what reason we know not. What money was needed for the support of the people was taken from the treasury of the city of Messina; for what the king of Naples sent was seized and spent by the garrison.

It is said that not more than 800 or 900 persons perished by this earthquake. The sea during that convulsion of the land was slightly agitated in the harbour. Farther out the sea was more violently agitated; but none of the ships in the harbour were dashed to pieces. The waters rose so high as to be injurious in a very considerable degree to Pharo, as well as along the coast of Scylla and Bagnara.

This earthquake was not of a momentary duration, like that by which Lisbon was destroyed, and like many others; for more than sixty days from the 5th of February to the beginning of April, Messina continued to be shaken, and in that time felt more than 200 shocks; and even after that period the alarm was again and again renewed. Not only the magistrates, the soldiers and the people, but the priests likewise, with their tabernacle and altar, retired to the barracks. The nuns, too, deserted their cloisters, and sought a retreat without the walls. Some of them confined themselves to the gardens of their convents; others mixed indiscriminately with the people.

The chief damage which the public buildings within the city suffered was the fall of the dome of the church of Purgatory. Only the walls were left standing; and even these had suffered considerably. One half of the steeple of the cathedral was beaten to the ground. The magazines of Porto Franco were likewise very much shattered. The fort of St Salvator, being built on an artificial foundation, the side next the sea is there fallen down; but on the other side, where it is founded on a rock, it has stood unmoved by all the shocks of the earthquake.

On the 5th of February, when the earthquake was more violent than at any time afterwards, a strong smell of sulphur was felt. The earth was affected somewhat in the same way as if it had been borne upon a fluid; and seemed to reel with the shocks much like a ship tossed with the waves. This tremulous motion was felt all over Sicily; but towards Pharo it became weaker. On the following days the sky was cloudy; the mountains of Sicily and the shores of Calabria continued covered with a thick fog like smoke. North and north-east winds raged with the most violent impetuosity.

The disastrous year of this earthquake was scarce concluded, the chasms which it had opened in the ground were still yawning, and the poor inhabitants of the adjacent country still trembled with terror, when the elements again renewed their fury to ravage this miserable land.

On Tuesday the 6th of January 1784, about sunrise, the wind began to blow softly from the north-east. The sea gradually swelled, rose beyond its bed with rapid impetuosity, overflowed the quay of Messina, and lashed with its billows the ruins of the Palazzata. It loosened and displaced many of the stones of the mole, spread over the whole street, and attacked the pedestals of the statues which had been spared by the earthquake, and still stood firm among the ruins. The same furious wind which swelled the sea in so extraordinary a manner, ravaged the whole coast from Messina all the way to Syracuse.

MESSUAGE, Messuagium, in *Law*, a dwelling-house, with some land adjoining assigned for its use. By the name of *messuage* may a garden, shop, mill, cottage, chamber, cellar, or the like, pass.—In Scotland, *messuage* denotes what is called in England the *manor-house*, viz. the principal dwelling-house within any barony.

MESOPORPHYRON, a name given by the Greeks to the Roman *laticlave;* because that garment being edged on each side, where it opened before, with purple, appeared when closed with two purple stripes down the middle. The same term was also applied to the *angusticlave*.

META, in the Roman circus, was a pile of stones of a pyramidical form, intended as a boundary of the *stadium*, or chariot course.—When the meta was passed the seventh time, the race was concluded. The greatest art and management were required in avoiding the meta, and yet going as near it as possible. If they went too near, they were in the greatest danger of breaking the chariot to pieces; and if they took too large a circuit in the turn, they gave their rivals an opportunity of getting within them, besides losing a great deal of ground. The boundary of the Grecian *stadium*, or course, was called τελος, τερμα, γραμμη and ακρα γραμμη; to which last name Horace probably alludes, in calling death "*ultima linea rerum*."

The *metæ* at Rome were first of wood, afterwards of stone; but the emperor Claudius made them of gold, or rather gilded them. In the Roman circus there were two *metæ*, one at the entrance of the course, and and the other at the end of it. An egg was placed upon the top of the *metæ*.

METACARPUS, or Metacarpium, (from μετα, *behind*, and καρπος, *hand*), in *Anatomy*, that part of the hand between the wrist and the fingers. See Anatomy, N° 55.

METAGITNION, the second month of the Athenian year, answering to the latter part of our July and the

the beginning of August, and so called from *metagitnia*, a festival in honour of Apollo, which was kept in it. The Bœotians called this month *panemus*, and the Syracusans, *carnius*.

METAL, in *Natural History*, is a substance which is distinguished from others by its ductility, malleability, tenacity, opacity, &c. for an account of which, see CHEMISTRY.

METAL, in *Heraldry*. There are two metals used in heraldry, by way of colours, viz. gold and silver, in blazon called *or* and *argent*.

In the common painting of arms these metals are represented by white and yellow, which are the natural colours of those metals. In engraving, gold is expressed by dotting the coat, &c. all over; and silver, by leaving it quite blank.

It is a general rule in heraldry, never to place metal upon metal, or colour upon colour: so that if the field be of one of the metals, the bearing must be of some colour; and if the field be of any colour, the bearing must be one of the metals.

METALEPSIS. See ORATORY, N° 59.

METALLISATION, is defined to be the natural process by which metals are formed in the bowels of the earth.

METALLURGY, in a more general sense, comprehends the whole art of working metals, from the state of ore to the utensil; and in this sense, essaying, smelting, refining, parting, smithery, gilding, &c. are only branches of metallurgy. But in a more limited sense it includes only the operations which are followed in separating metals from their ores. For an account of these processes, see ORES, *Reduction of;* and for the practical branches, see GILDING, PARTING, PURIFYING, REFINING, SMITHERY.

METAMORPHOSIS, in general, denotes the changing of something into a different form; in which sense it includes the transformation of insects, as well as the mythological changes related by the ancient poets.

Mythological metamorphoses were held to be of two kinds, apparent and real: thus, that of Jupiter into a bull, was only apparent; whereas that of Lycaon into a wolf, was supposed to be real.

Most of the ancient metamorphoses include some allegorical meaning, relating either to physics or morality; some authors are even of opinion that a great part of the ancient philosophy is couched under them; and Lord Bacon and Dr Hooke have attempted to unriddle several of them.

METAPHOR, in *Rhetoric*. See ORATORY, N° 54.

METAPHOR *and Allegory*, in poetry.—A metaphor differs from a simile, in form only, not in substance: in a simile the two subjects are kept distinct in the expression, as well as in the thought; in a metaphor, the two subjects are kept distinct in the thought only, not in the expression. A hero resembles a lion, and upon that resemblance many similies have been raised by Homer and other poets. But instead of resembling a lion, let us take the aid of the imagination, and feign or figure the hero to be a lion; by that variation the simile is converted into a metaphor; which is carried on by describing all the qualities of a lion that resemble those of the hero. The fundamental pleasure here, that of resemblance, belongs to the thought. An additional pleasure arises from the expression: the poet, by figuring his hero to be a lion, goes on to describe the lion in appearance, but in reality the hero; and his description is peculiarly beautiful, by expressing the virtues and qualities of the hero in new terms, which, properly speaking, belong not to him, but to the lion. This will better be understood by examples. A family connected with a common parent, resembles a tree, the trunk and branches of which are connected with a common root: but let us suppose, that a family is figured, not barely to be like a tree, but to be a tree; and then the simile will be converted into a metaphor, in the following manner:

Edward's sev'n sons, whereof thyself art one,
Were sev'n fair branches, springing from one root;
Some of these branches by the dest'nies cut:
But Thomas, my dear lord, my life, my Glo'ster,
One flourishing branch of his most royal root,
Is hack'd down, and his summer leaves all faded,
By Envy's hand and Murder's bloody axe.
Richard II. act i. sc. 3.

Figuring human life to be a voyage at sea.

There is a tide in the affairs of men,
Which, taken at the flood, leads on to Fortune:
Omitted, all the voyage of their life
Is bound in shallows and in miseries.
On such a full sea are we now afloat:
And we must take the current when it serves,
Or lose our ventures. *Julius Cæsar*, act iv. sc. 5.

Figuring glory and honour to be a garland of flowers:

Hotspur.——————Wou'd to heav'n,
Thy name in arms were now as great as mine!
Pr. Henry. I'll make it greater ere I part from thee;
And all the budding honours on thy crest
I'll crop, to make a garland for my head.
First Part of Henry IV. act v. sc. 9.

Figuring a man who hath acquired great reputation and honour to be a tree full of fruit:

——————Oh, boys, this story
The world may read in me; my body's mark'd
With Roman swords; and my report was once
First with the best of note. Cymbeline lov'd me;
And when a soldier was the theme, my name
Was not far off; then was I as a tree,
Whose boughs did bend with fruit. But in one night,
A storm or robbery, call it what you will,
Shook down my mellow hangings, nay, my leaves;
And left me bare to wither.
Cymbeline, act iii. sc. 3.

" Blest be thy soul, thou king of shells, said Swaran of the dark-brown shield. In peace, thou art the gale of spring; in war, the mountain-storm. Take now my hand in friendship, thou noble king of Morven."
Fingal.

" Thou dwellest in the soul of Malvina, son of mighty Ossian. My sighs arise with the beam of the east: my tears descend with the drops of night. I was a lovely tree in thy presence, Oscar, with all my branches round me: but thy death came like a blast from the desert, Metaphor. desert, and laid my green head low; the spring returned with its showers, but no leaf of mine arose."

Fingal.

An *allegory* differs from a metaphor; and a *figure of speech* differs from both. A metaphor is defined above to be an act of the imagination, figuring one thing to be another. An allegory requires no such operation, nor is one thing figured to be another: it consists in choosing a subject having properties or circumstances resembling those of the principal subject: and the former is described in such a manner as to represent the latter: the subject thus represented is kept out of view: we are left to discover it by reflection; and we are pleased with the discovery, because it is our own work. (See the word ALLEGORY.)

Quintilian gives the following instance of an allegory.

O navis, referent in mare te novi
Fluctus. O quid agis? fortiter occupa portum.
Horat. lib. ode 14.

and explains it elegantly in the following words: "Totusque ille Horatii locus, quo navim pro republica, fluctuum tempestates pro bellis civilibus, portum pro pace atque concordia, dicit."

In a *figure of speech*, there is no fiction of the imagination employed, as in a metaphor; nor a representative subject introduced, as in an allegory. This figure, as its name implies, regards the expression only, not the thought; and it may be defined, the using a word in a sense different from what is proper to it.—Thus youth, or the beginning of life, is expressed figuratively by *morning of life*: morning is the beginning of the day; and in that view it is employed to signify the beginning of any other series, life especially, the progress of which is reckoned by days. See FIGURE *of Speech.*

Metaphor and *allegory* are so much connected, that it seemed proper to handle them together: the rules particularly for distinguishing the good from the bad, are common to both. We shall therefore proceed to those rules, after adding some examples to illustrate the nature of an *allegory*, which, with a view to this article, was but slightly illustrated under its proper name.

Horace, speaking of his love to Pyrrha, which was now extinguished, expressed himself thus:

————Me tabulâ sacer
Votivâ paries indicat uvida
Suspendisse potenti
Vestimenta maris Deo. *Carm.* lib. i. ode 5.

Again:
Phœbus volentem prælia me loqui,
Victas et urbes, increpuit, lyra
Ne parva Tyrrhenum per æquor
Vela darem. *Carm.* lib. iv. ode 15.

Queen. Great lords, wise men ne'er sit and wail their loss,
But cheerly seek how to redress their harms.
What though the mast be now blown overboard,
The cable broke, the holding anchor lost,
And half our sailors swallowed in the flood!
Yet lives our pilot still. Is't meet that he
Should leave the helm, and, like a fearful lad,
With tearful eyes add water to the sea,
And give more strength to that which hath too much;
While in his moan the ship splits on the rock,
Which industry and courage might have sav'd?
Ah, what a shame! ah, what a fault were this!
Third Part of Henry VI. act v. sc. 5.

Oroonoko. Ha! thou has rous'd
The lion in his den; he stalks abroad,
And the wide forest trembles at his roar.
I find the danger now. *Oroonoko*, act. iii. sc. 2.

"My well beloved hath a vineyard in a very fruitful hill. He fenced it, gathered out the stones thereof, planted it with the choicest vine, built a tower in the midst of it, and also made a wine press therein; he looked that it should bring forth grapes, and it brought forth wild grapes. And now, O inhabitants of Jerusalem, and men of Judah, judge, I pray you, betwixt me and my vineyard. What could have been done more to my vineyard, that I have not done? Wherefore, when I looked that it should bring forth grapes, brought it forth wild grapes? And now go to, I will tell you what I will do to my vineyard: I will take away the hedge thereof, and it shall be eaten up; and break down the wall thereof, and it shall be trodden down. And I will lay it waste: it shall not be pruned, nor digged, but there shall come up briars and thorns: I will also command the clouds that they rain no rain upon it. For the vineyard of the Lord of hosts is the house of Israel, and the men of Judah his pleasant plant." *Isaiah* v. 1.

The rules that govern metaphors and allegories are of two kinds. The construction of these figures comes under the first kind: the propriety or impropriety of introduction comes under the other.—To begin with rules of the first kind; some of which coincide with those already given for similies; some are peculiar to metaphors and allegories.

In the first place, It has been observed, that a simile cannot be agreeable where the resemblance is either too strong or too faint. This holds equally in metaphor and allegory; and the reason is the same in all. In the following instances, the resemblance is too faint to be agreeable.

Malcolm. ————But there's no bottom, none,
In my voluptuousness: your wives, your daughters,
Your matrons, and your maids, could not fill up
The cistern of my lust. *Macbeth*, act iv. sc. 4.

The best way to judge of this metaphor, is to convert it into a simile: which would be bad, because there is scarce any resemblance between lust and a cistern, or betwixt enormous lust and a large cistern.

Again:
He cannot buckle his distemper'd cause
Within the belt of rule. *Macbeth*, act v. sc. 2.

There is no resemblance between a distempered cause and any body that can be confined within a belt.

Again:
Steep me in poverty to the very lips.
Othello, act iv. sc. 9.

Poverty

Metaphor. Poverty here must be conceived a fluid, which it resembles not in any manner.

Speaking to Bolingbroke banished for six years:

> The sullen passage of thy weary steps
> Esteem a soil, wherein thou art to set
> The precious jewel of thy home return.
> *Richard II.* act ii. sc. 6.

Again:

> Here is a letter, lady,
> And every word in it a gaping wound
> Issuing life-blood.
> *Merchant of Venice*, act. iii. sc. 3.

> Tantæ *molis* erat Romanam condere gentem.
> *Æneid.* i. 37.

The following metaphor is strained beyond all endurance: Timur-bec, known to us by the name of *Tamerlane the Great*, writes to Bajazet emperor of the Ottomans in the following terms:

"Where is the monarch who dares resist us? where is the potentate who doth not glory in being numbered among our attendants? As for thee, descended from a Turcoman sailor, since the vessel of thy unbounded ambition hath been wreck'd in the gulf of they self-love, it would be proper, that thou shouldst take in the sails of thy temerity, and cast the anchor of repentance in the port of sincerity and justice, which is the port of safety; lest the tempest of our vengeance make thee perish in the sea of the punishment thou deservest."

Such strained figures, as observed above, are not unfrequent in the first dawn of refinement; the mind in a new enjoyment knows no bounds, and is generally carried to excess, till taste and experience discover the proper limits.

Secondly. Whatever resemblance subjects may have, it is wrong to put one for another, where they bear no mutual proportion. Upon comparing a very high to a very low subject, the simile takes on an air of burlesque: and the same will be the effect where the one is imagined to be the other, as in a metaphor; or made to represent the other, as in an allegory.

Thirdly. These figures, a metaphor especially, ought not to be crowded with many minute circumstances; for in that case it is scarcely possible to avoid obscurity. A metaphor above all ought to be short: it is difficult, for any time, to support a lively image of a thing being what we know it is not; and for that reason, a metaphor drawn out to any length, instead of illustrating or enlivening the principal subject, becomes disagreeable by overstraining the mind. Here Cowley is extremely licentious. Take the following instance.

> Great and wise conqu'ror, who where'er
> Thou com'st, dost fortify and settle there!
> Who canst defend as well as get;
> And never hadst one quarter beat up yet;
> Now thou art in, thou ne'er will part
> With one inch of my vanquish'd heart;
> For since thou took'st it by assault from me
> 'Tis garrison'd so strong with thoughts of thee,
> It fears no beauteous enemy.

For the same reason, however agreeable long allegories may at first be by their novelty, they never afford any lasting pleasure: witness the *Faëry Queen*, which with great power of expression, variety of images, and melody of versification, is scarce ever read a second time.

In the fourth place. The comparison carried on in a simile, being in a metaphor sunk by imagining the principal subject to be that very thing which it only resembles; an opportunity is furnished to describe it in terms taken strictly or literally with respect to its imagined nature. This suggests another rule, That in constructing a metaphor, the writer ought to make use of such words only as are applicable literally to the imagined nature of his subject: figurative words ought carefully to be avoided; for such complicated figures, instead of setting the principal subject in a strong light, involve it in a cloud, and it is well if the reader, without rejecting by the lump, endeavour patiently to gather the plain meaning, regardless of the figures:

> A stubborn and unconquerable flame
> Creeps in his veins, and drinks the streams of life.
> *Lady Jane Gray*, act i. sc. 1.

Copied from Ovid:

> Sorbent avidæ præcordia flammæ.
> *Metamorph.* lib. ix. 172.

Let us analyze this expression. That a fever may be imagined a flame, we admit: though more than one step is necessary to come at the resemblance: a fever, by heating the body, resembles fire; and it is no stretch to imagine a fever to be a fire: again, by a figure of speech, flame may be put for fire, because they are commonly conjoined; and therefore a fever may be termed a *flame*. But now admitting a fever to be a flame, its effects ought to be explained in words that agree literally to a flame. This rule is not observed here; for a flame drinks figuratively only, not properly.

King Henry to his son Prince Henry:

> Thou hid'st a thousand daggers in thy thoughts,
> Which thou hast whetted on thy stony heart
> To stab at half an hour of my frail life.
> *Second Part Henry IV.* act iv. sc. 11.

Such faulty metaphors are pleasantly ridiculed in the *Rehearsal*:

Physician. Sir, to conclude, the place you fill has more than amply exacted the talents of a wary pilot; and all these threatening storms, which, like impregnate clouds, hover o'er our heads, will, when they once are grasp'd but by the eye of reason, melt into fruitful showers of blessings on the people.

"*Bayes.* Pray mark that allegory. Is not that good?

"*Johnson.* Yes, that grasping of a storm with the eye is admirable. Act ii. sc. 1.

Fifthly. The jumbling different metaphors in the same sentence, beginning with one metaphor and ending with another, commonly called a *mixt metaphor*, ought never to be indulged.

K. Henry.

K. Henry. ———Will you again unknit
This churlish knot of all abhorred war,
And move in that obedient orb again,
Where you did give a fair and natural light?
First Part Henry VI. act. v. sc. 1.

Whether 'tis nobler in the mind, to suffer
The stings and arrows of outrageous fortune;
Or to take arms against a sea of troubles,
And by opposing end them.
Hamlet, act iii. sc. 2.

In the sixth place, It is unpleasant to join different metaphors in the same period, even where they are preserved distinct: for when the subject is imagined to be first one thing and then another in the same period without interval, the mind is distracted by the rapid transition; and when the imagination is put on such hard duty, its images are too faint to produce any good effect:

At regina gravi jamdudum saucia cura,
Vulnus alit venis, et cæco carpitur igni.
Æneid. iv. 1.

——————Est mollis flamma medullas
Interea, et tacitum vivit sub pectore vulnus.
Æneid. iv. 66.

Motum ex Metello consule civicum,
Bellique causas, et vitia, et modos,
Ludumque fortunæ, gravesque
Principum amicitias, et arma
Nondum expiatis uncta cruoribus,
Periculosæ plenum opus aleæ,
Tractas, et incedis per ignes
Suppositos cineri doloso.
Horat. Carm. lib. ii. ode 1.

In the last place, It is still worse to jumble together metaphorical and natural expression, so as that the period must be understood in part metaphorically, in part literally; for the imagination cannot follow with sufficient ease changes so sudden and unprepared: a metaphor begun and not carried on, hath no beauty; and instead of light there is nothing but obscurity and confusion. Instances of such incorrect composition are without number: we shall, for a specimen, select a few from different authors. Speaking of Britain,

——This precious stone set in the sea,
Which serves it in the office of a wall,
Or as a moat defensive to a house,
Against the envy of less happier lands.
Richard II. act ii. sc. 1.

In the first line Britain is figured to be a precious stone: in the following line, Britain, divested of her metaphorical dress, is presented to the reader in her natural appearance.

These growing feathers pluck'd from Cæsar's wing,
Will make him fly an ordinary pitch,
Who else would soar above the view of men,
And keep us all in servile fearfulness.
Julius Cæsar, act i. sc. 1.

Rebus angustis animosus atque
Fortis adpare: sapienter idem
Contrahes vento nimium secundo
Turgida vela. *Hor. Carm.* lib. ii. ode 10.

The following is a miserable jumble of expressions, arising from an unsteady view of the subject, between its figurative and natural appearance:

But now from gath'ring clouds destruction pours,
Which ruins with mad rage our halcyon hours:
Mists from black jealousies the tempest form,
Whilst late divisions reinforce the storm.
Dispensary, canto iii.

To thee the world its present homage pays,
The harvest early, but mature the praise.
Pope's Imitation of Horace, book ii.

Oui, sa pudeur ne'st que franche grimace,
Qu'une ombre de vertu qui garde mal la place,
Et qui s'evanouit, comme l'on peut savoir,
Aux rayons du soleil qu'une bourse vait voir.
Moliere, L'Etourdi, act iii. sc. 2.

Et son feu, de pourvû de sense et de lecture,
S'éteint à chaque pas, faut de nourriture.
Boileau, L'Art Poetique, chant. iii. l. 319.

Dryden, in his dedication of the translation of *Juvenal*, says, "When thus, as I may say, before the use of the loadstone, or knowledge of the compass, I was sailing in a vast ocean, without other help than the pole-star of the ancients, and the rules of the French stage among the moderns," &c.

"There is a time when factions, by the vehemence of their own fermentation, stun and disable one another." *Bolingbroke*.

This fault of jumbling the figure and plain expression into one confused mass, is not less common in allegory than in metaphor.

Take the following examples:

——————Heu! quoties fidem,
Mutatosque Deos flebit, et aspera
Nigris æquora ventis
Emirabitur insolens,
Qui nunc te fruitur credulus aureâ:
Qui semper vacuam, semper amabilem
Sperat, nescius auræ
Fallacis. *Horat. Carm.* lib. i. ode 5.

Pour moi sur cette mer, qu'ici bas nous courons,
Je songe à me pourvoir d'esquif et d'avirons,
A regler mes desires, à prévenir l'orage,
Et sauver, s'il se peut, ma Raison du naufrage.
Boileau, epitre 5.

Lord Halifax, speaking of the ancient fabulists: "They (says he) wrote in signs, and spoke in parables: all their fables carry a double meaning: the story is one, and entire; the characters the same throughout; not broken or changed, and always conformable to the nature of the creature they introduce. They never tell you, that the dog which snapped at a shadow, lost his troop of horse; that would be unintelligible. This is his

Metaphor.

his (Dryden's) new way of telling a story, and confounding the moral and the fable together." After instancing from the Hind and Panther, he goes on thus: "What relation has the hind to our Saviour? or what notion have we of a panther's bible? If you say he means the church, how does the church feed on lawns, or range in the forest? Let it be always a church, or always a cloven-footed beast; for we cannot bear his shifting the scene every line."

A few words more upon allegory. Nothing gives greater pleasure than this figure, when the representative subject bears a strong analogy, in all its circumstances, to that which is represented: but the choice is seldom so lucky; the analogy being generally so faint and obscure, as to puzzle and not please. An allegory is still more difficult in painting than in poetry: the former can show no resemblance but what appears to the eye; the latter hath many other resources for showing the resemblance. And therefore, with respect to what the abbé du Bos terms *mixt allegorical compositions*, these may do in poetry; because, in writing, the allegory can easily be distinguished from the historical part: no person, for example, mistakes Virgil's Fame for a real being. But such a mixture in a picture is intolerable; because in a picture the objects must appear all of the same kind, wholly real or wholly emblematical. For this reason, the history of Mary de Medicis, in the palace of Luxembourg, painted by Rubens, is unpleasant by a perpetual jumble of real and allegorical personages, which produce a discordance of parts, and an obscurity upon the whole: witness, in particular, the tablature representing the arrival of Mary de Medicis at Marseilles; where, together with the real personages, the Nereids and Tritons appear sounding their shells: such a mixture of fiction and reality in the same group is strangely absurd. The picture of Alexander and Roxana, described by Lucian, is gay and fanciful; but it suffers by the allegorical figures. It is not in the wit of man to invent an allegorical representation deviating farther from any shadow of resemblance, than one exhibited by Louis XIV. anno 1664; in which an enormous chariot, intended to represent that of the sun, is dragged along, surrounded with men and women, representing the four ages of the world, the celestial signs, the seasons, the hours, &c. a monstrous composition, and yet scarcely more absurd than Guido's tablature of Aurora.

In an allegory, as well as in a metaphor, terms ought to be chosen that properly and literally are applicable to the representative subject: nor ought any circumstance to be added that is not proper to the representative subject, however justly it may be applicable properly or figuratively to the principal. The following allegory is therefore faulty:

> Ferus et Cupido,
> Semper ardentes acuens sagittas
> Cote *cruentâ*. *Horat.* lib. ii. ode 8.

For though blood may suggest the cruelty of love, it is an improper or immaterial circumstance in the representative subject: water, not blood, is proper for a whetstone.

We proceed to the next head, which is, to examine in what circumstances these figures are proper, in what improper. This inquiry is not altogether superseded by what is said upon the same subject in the article COMPARISON; because, upon trial, it will be found, that a short metaphor or allegory may be proper, where a simile, drawn out to a greater length, and in its nature more solemn, would scarcely be relished.

And, in the first place, A metaphor, like a simile, is excluded from common conversation, and from the description of ordinary incidents. Secondly, In expressing any severe passion that totally occupies the mind, metaphor is unnatural.

The following example, of deep despair, beside the highly figurative style, has more the air of raving than of sense:

> *Calista.* Is it the voice of thunder, or my father?
> Madness! confusion! let the storm come on,
> Let the tumultuous roar drive all upon me,
> Dash my devoted bark; ye surges, break it:
> 'Tis for my ruin that the tempest rises.
> When I am lost, sunk to the bottom low,
> Peace shall return, and all be calm again.
> *Fair Penitent*, act. v.

The following metaphor is sweet and lively; but it suits not the fiery temper of Chamont, inflamed with passion: parables are not the language of wrath venting itself without restraint:

> *Chamont.* You took her up a little tender flow'r,
> Just sprouted on a bank, which the next frost
> Had nipp'd; and with a careful loving hand,
> Transplanted her into your own fair garden,
> Where the sun always shines: there long she flourish'd,
> Grew sweet to sense, and lovely to the eye;
> Till at the last a cruel spoiler came,
> Cropt this fair rose, and rifled all its sweetness,
> Then cast it like a loathsome weed away.
> *Orphan*, act. iv.

The following speech, full of imagery, is not natural in grief and dejection of mind.

> *Gonsalez.* O my son! from the blind dotage
> Of a father's fondness these ills arose.
> For thee I've been ambitious, base, and bloody:
> For thee I've plung'd into this sea of sin;
> Stemming the tide with only one weak hand,
> While t'other bore the crown (to wreathe thy brow),
> Whose weight has sunk me ere I reach'd the shore.
> *Mourning Bride*, act. v. sc. 6.

There is an enchanting picture of deep distress in Macbeth, where Macduff is represented lamenting his wife and children, inhumanly murdered by the tyrant. Stung to the heart with the news, he questions the messenger over and over: not that he doubted the fact, but that his heart revolted against so cruel a misfortune. After struggling some time with his grief, he turns from his wife and children to their savage butcher: and then gives vent to his resentment, but still with manliness and dignity;

> O, I could play the woman with mine eyes,
> And braggart with my tongue. But, gentle Heav'n!
> Cut short all intermission; front to front
> Bring thou this fiend of Scotland and myself;

Within

Within my sword's length set him. If he 'scape,
Then Heav'n forgive him too.

Metaphorical expression, indeed, may sometimes be used with grace where a regular simile would be intolerable: but there are situations so severe and dispiriting, as not to admit even the slightest metaphor. It requires great delicacy of taste to determine with firmness, whether the present case be of that nature: perhaps it is; yet who could wish a single word of this admirable scene altered?

But metaphorical language is proper when a man struggles to bear with dignity or decency a misfortune however great; the struggle agitates and animates the mind:

Wolsey. Farewell, a long farewell to all my greatness;
This is the state of man: to-day he puts forth
The tender leaves of hope; to-morrow blossoms,
And bears his blushing honours thick upon him;
The third day comes a frost, a killing frost,
And when he thinks, good easy man, full surely
His greatness is a-ripening, nips his root,
And then he falls as I do. *Henry VIII.* act iii. sc. 6.

METAPHRAST, a translator, or person who renders an author into another form or another language, word for word.

METAPHYSICS.

1 Definition.

METAPHYSICS has been defined, by a writer deeply read in the ancient philosophy, "The science of the principles and causes of all things existing." This definition we think extremely proper: and hence it is, that *mind* or intelligence, and especially the *supreme intelligence*, which is the cause of the universe, and of every thing which it contains, is the principal subject of this science; and hence, too, the science itself received its name. Aristotle, indeed, who, of all the ancient metaphysicians whose works have come down to us, was unquestionably the greatest, calls this science THE FIRST PHILOSOPHY, as being not only superior, but also prior in the order of nature, to the whole circle of the other arts and sciences. But, "what is first to nature, is not first to man." Nature begins with *causes*, which produce *effects*. Man begins with *effects*, and by them ascends to *causes*. Thus all human study and investigation proceed of necessity in the reverse of the natural order of things, from *sensible* to *intelligible*, from *body* the effect, to *mind*, which is both the first and the final cause. Now PHYSICS being the name given by the Stagyrite to the philosophy of body, some of his interpreters, from this necessary course of human studies, called that of mind METAPHYSICS, implying by that term not only that its subject is more sublime and difficult, but also that the study of it would be most properly and successfully entered upon AFTER THAT OF PHYSICS. To this name, which, though it has sometimes been treated with ridicule, is abundantly significant, the followers of Aristotle were led by their master, who, to the books in which he pretends to elevate the mind above things corporeal to the contemplation of God and things spiritual, prefixed the Greek words *μετα τα φυσικα* (A).

2 Division of the science

The science of Metaphysics has been divided, according to the objects which it considers, into six principal parts, which are called, 1. *Ontology*; 2. *Cosmology*; 3. *Anthroposophy*; 4. *Psychology*; 5. *Pneumatology*; and, 6. *Metaphysical theology*.

3 Ontology;

1. That part of the science which is named *ontology*, investigates and explains the nature and essence of all beings, as well as the qualities and attributes that essentially appertain to them. Hence it has been said that ontology should proceed in its operations from the most simple ideas; such as do not admit of any other qualities of which they may be compounded. These simple ideas are of *being*, of *essence*, of *substance*, of *mode*, of *existence* as well with regard to time as place, of a *necessary cause* of *unity*; the idea of *negation*; the difference between a *being* that is *simple* or *compound*, *necessary* or *accidental*, *finite* or *infinite*; the ideas of *essential* and *abstract properties*, such as of the *greatness*, *perfection*, and *goodness* of *beings*, &c. The business therefore of ontology, is to make us acquainted with every kind of being in its nature and essential qualities, which distinguish it from all other beings. This knowledge being once established on simple principles, just consequences may thence be drawn, and those things proved after which the metaphysician inquires, and which is the business of his science to prove.

It is easy to conceive, that even a clear knowledge of beings, and their essential properties, would be still defective and useless to man, if he did not know how to determine and fix his ideas by proper denominations, and consequently to communicate his perceptions to those whom he would instruct, or against whom he is obliged to dispute. To render our ideas therefore intelligible to others, we must have determinate words or denominations for each being, and the qualities of each being; and ontology teaches us those terms which are so necessary to fix our ideas, and to give them the requisite perspicuity and precision, that when we endeavour to extend the sphere of

(A) ΤΩΝ ΜΕΤΑ ΤΑ ΦΥΣΙΚΑ. Cujus inscriptionis hæc ratio est, quod in hoc opere ea tractantur quorum theoria posterior est doctrinæ naturali saltem quoad nos, qui à corporum cognitione rerumque caducarum in substantiarum immaterialium atque immortalium contemplationem provehimur.

Du Val. Synops. Doctr. Peripat.

Divisions of the Science. of our knowledge, we may not waste our time in disputes about words.

4 Cosmology; 2. Metaphysics, having, in as solid a manner as possible, explained and established the principles above mentioned, continues its inquiries to the second part, which is called *cosmology*, and examines into the essence of the world and all that it contains; its eternal laws; of the nature of matter; of motion; of the nature of tangible bodies, their attributes and adjuncts; and of all that can be known by reasoning and experience. It is also in cosmology that the metaphysicians of this school examine the Leibnitzian system; that is, whether God, in creating the world, must necessarily have created the best world; and if this world be so in fact. In this manner they pursue the argument, from consequence to consequence, to its last resort, frequently with very little advantage to truth and science.

5 Anthroposophy; 3. *Anthroposophy*, or the knowledge of man, forms the third branch of metaphysics. It is subdivided into two parts. The first, which consists in the knowledge of the exterior parts of the human frame, belongs not to this science, but to Anatomy and Physiology. The business of the metaphysician is here to ascertain the nature of those powers by which all the motions essential to life are produced; and to discover, if possible, whether they be corporeal or spiritual. This inquiry leads at the same time to

6 Psychology; 4. *Psychology*; which consists in the knowledge of the intellectual soul in particular; concerning which the most profound, the most subtle, and most abstract researches, have been made that human reason is capable of: and concerning the substance of which, in spite of all these efforts, it is yet extremely difficult to support any positive opinion with conclusive or probable arguments.

7 Pneumatology; 5. The fifth part of metaphysics is called *pneumatology*. By this term, which has not been long in use, metaphysicians mean the knowledge of all spirits, *angels*, &c. It is easy to conceive what infinite art is necessary to give an account of that, of which nothing positive can ever be known in the present state of human existence. But the metaphysician of this school readily offers to show us, "what is the idea of a spirit; the effective existence of a spirit; what are its general qualities and properties; that there are rational spirits, and that these rational spirits have qualities that are founded in the moral attributes of God:" for this is in so many words what is attempted to be taught in pneumatology.

8 Metaphysical theology. 6. *Metaphysical theology*, which Leibnitz and some others call *theodicy*, is the sixth and last branch of the science of metaphysics. It teaches us the knowledge of the existence of God; to make the most rational suppositions concerning his divine essence, and to form a just idea of his attributes and perfections, and to demonstrate them by abstract reasoning. Theodicy differs from natural theology, in as much as this last borrows, in fact, from theodicy proofs and demonstrations to confirm the existence of a supreme Being: but after having solidly established that great truth, by extending its consequences natural theology teaches us what are the relations and connexions that subsist between the supreme Being and men, and what are the duties which result from these relations.

We have briefly mentioned these divisions of the science, because they were once prevalent in the schools. The greater part of them, however, appears to us to be not only superfluous, but such as can serve no other purpose than to perplex the mind. The only beings of which we know any thing are mind and body; and we have no reason to think that there are any other beings in the universe. Of bodies indeed there are various kinds, endowed with different properties: and it is extremely probable, that of minds endowed with different powers, the variety may be equally great. Our own minds we know to be united in one system with bodies by which they perform all their operations; and we can demonstrate that there is another Mind, which is independent of all body, and is the cause of all things. Between these there may be numberless orders of minds; but their energies are wholly unknown to us, and therefore they can never become the objects of science.

Divisions of the Science. 9 This division useless and improper.

Mind and body therefore, *i. e.* the minds and bodies which we know to exist, together with their powers and properties, essential and accidental, can alone be the subjects of rational inquiry. We may inquire into the essence of mind and the essence of body, and endeavour to ascertain in what respects they differ. We may examine the nature of different bodies, in order to discover whether all bodies, however modified, have not something in common; and we may consider the properties, relations, and adjuncts of bodies, and endeavour to distinguish those which are accidental from such as appear to be so necessary that without them body itself could not exist. Of minds we cannot make the same comparison. In this part of the science we have not sufficient data for an accurate and complete induction: we can only examine the powers of our own mind; and by probable analogy make some estimate of the powers of superior minds, as observation will help us to guess at the powers of those which are placed beneath us in the scale of existence.

If this be so, Cosmology, as distinguished from Ontology, cannot properly be a branch of Metaphysics. For if mind and body, with their several powers, properties, and adjuncts, compose the universe, it is obvious, that when we have ascertained, as well as we are able, the essence of mind and the essence of body, together with the powers and properties of each, and have traced them all to the first cause, we have done every thing in the science of the universe, if we may use the expression, which belongs to the province of the metaphysician. The particular laws of motion on the earth and in the planetary system belong to the natural philosopher and astronomer.

In like manner, Anthroposophy, Psychology, or Pneumatology, if they be not words expressive of distinctions where there is no difference, seem to be at least very needlessly disjoined from each other. Of the nature of spirits we can know nothing but from contemplating the powers of our own minds; and the body of man is in the province, not of the metaphysician, but of the anatomist and physiologist. Anthroposophy, psychology, and pneumatology, if they be used to denote our knowledge of all minds except the Supreme, are words of the same import; for of no created minds except our own can we acquire such knowledge as deserves the name of science.

Ontology

Divisions of the Science.

Ontology has sometimes been defined the science of *being in the abstract;* but in the course of our inquiries it will be seen, that *being in the abstract* is a phrase without meaning. Considered as the science of *real beings* and their *properties*, Ontology is a very significant word, of the same import with Metaphysics, comprehending in itself the knowledge of the nature of all things existing. Or if it be thought proper to make a distinction between ontology and theology, the former branch of the science will teach the knowledge of body and created minds, whilst it is the province of the latter to demonstrate the existence and attributes of that mind which is uncreated.

Body and mind, therefore, with their properties, adjuncts, and powers, comprehend the whole subject of the science of metaphysics; and as we are earlier acquainted with body than with mind, the natural order of conducting our inquiries seems to be, to begin with the former, and thence proceed to the latter. It is obvious, however, that if we would pursue these inquires with any hopes of success, we must first trace human knowledge from its source, ascertain the nature of truth, and show what kind of evidence on each topic to be treated ought to enforce conviction. In this view of the science, metaphysics appears to be divided into three parts; the first treating *of human understanding;* the second, *of body with its adjuncts;* and the third, *of mind with its powers.*

Previous to the entering upon such inquiries, some philosophers of great merit have thought it expedient to explain the terms which they might have occasion to use. Their conduct is judicious and worthy of imitation; for the objects of metaphysics being, for the most part, such as fall not under the cognizance of the senses, are liable to be differently apprehended by different men, if the meanings of the words by which they are expressed be not ascertained with the utmost precision. We intend, however, to use very few words but in the common acceptation; and we therefore hope, that as terms of science are explained under different words in the Dictionary, to which references are made, we have little or no occasion for swelling the article by previous definitions. There are indeed two words which have given rise to much useless disputation, which yet cannot be banished from speculative philosophy, and which it will therefore be proper here to define. The words to which we allude are *idea* and *notion.* These are very generally considered as synonymous; but we think that much logomachy might have been avoided by assigning to each a determinate signification. We know not any philosopher who made much use of the word *idea* before Plato; but with his mysterious doctrine concerning ideas we have here nothing to do: our present business is to ascertain the precise meaning of the word, which is evidently derived from εἰδω to *see*, as the word *notion* is from "nosco, novi, *notum*," and that from γινωσκω to *know* or *understand.* In the original sense of the two words, therefore, *notion* is more comprehensive than *idea*, because we *know* many things which cannot be *seen.* We have not a doubt, but that at first the word *idea* was employed to denote only those forms of external objects which men contemplate in their imaginations, and which are originally received through the sense of *sight.* Its signification was afterwards extended to the relicts of every sensation, of touch, taste, sound, and smell, as well as of sight; and at last it was confounded with *notion*, which denotes the mental apprehension of whatever may be known. In our use of the word *idea*, except when we quote from others, we shall employ it only to denote that appearance which absent objects of sense make in the memory or imagination (B); and by the word *notion* we shall denote our apprehension or knowledge of spirits, and all such things as, though they be the objects of science, cannot be perceived by the external senses. Having said this, we proceed to our inquiries, beginning with that into human understanding.

PART I. OF HUMAN UNDERSTANDING.

Preliminary Observations on the Origin *of our* Ideas *and* Notions.

THAT the mind of man has no innate ideas or notions, but comes into the world ignorant of every thing, is a truth which since the days of Locke has been very little disputed. In the first book of his Essay on the Human Understanding, that acute philosopher has demonstrated, that the rudiments or first principles of all our knowledge are communicated to us by sensation; and he has compared the mind, previous to the operation of external objects upon the senses, to a *tabula rasa* or sheet of white paper. To repeat his arguments would swell the article to no purpose. There is not a man capable of attending to his own ideas, who

(B) In thus restricting the meaning of the word *idea*, we have the honour to agree with the great English Lexicographer.—"He was particularly indignant against the almost universal use of the word *idea* in the sense of *notion* or *opinion*, when it is clear that *idea* can only signify something of which an image may be formed in the mind. We may have an *idea* or *image* of a mountain, a tree, or a building: but we cannot surely have an *idea* or *image* of an *argument* or *proposition.* Yet we hear the sages of the law delivering their *ideas* upon the question under consideration; and the first speakers in Parliament entirely coinciding in the *idea*, which has been so ably stated by an honourable member; or representing an *idea* as unconstitutional, and fraught with the most dangerous consequences to a great and free country. This Johnson called *modern cant.*" *Boswell's Life of Johnson.*

Origin of Ideas and Notions.

who can entertain a doubt in what manner he received them. Without the sense of sight, we could never have known colours; nor sound, without hearing; nor hardness, softness, smoothness, pain, or bodily pleasure, without touch; nor odours, without smell, &c.

Self-evident as these facts are, objections have been started to the inferences drawn from them; and Locke has been accused of advancing principles subversive of all distinction between truth and falsehood, and favourable of course to universal scepticism.—"The first book of his Essay, which, with submission, (says Dr Beattie*) I think the worst, tends to establish this dangerous doctrine, that the human mind, previous to education and habit, is as susceptible of one impression as of another: a doctrine which, if true, would go near to prove, that truth and virtue are no better than human contrivances; or at least that they have nothing permanent in their nature, but may be as changeable as the inclinations and capacities of men; and that there is no such thing as common sense in the world. Surely this is not the doctrine which Mr Locke meant to establish." We are so thoroughly satisfied that it is not, that we cannot help wondering how such inferences could, by a man of learning, genius, and candour, be drawn from any thing which is to be found in the Essay on the Human Understanding.

* *Essay on the Nature and Immutability of Truth.*

But the Doctor thinks Mr Locke's "simile of the mind to white paper one of the most unlucky allusions that could have been chosen; because the human soul, when it begins to think, is not extended, nor of a white colour, nor incapable of energy, nor wholly unfurnished with ideas, nor as susceptible of one impression or character as of any other:" and it has been observed by another objector†, that "on a sheet of white paper you may write that sugar is bitter; wormwood sweet; fire and frost in every degree pleasing and sufferable: that compassion and gratitude are base; treachery, falsehood, and envy, noble; and that contempt is indifferent to us."

† *J. Usher, author of* Clio. See a *vol. of Fugitive Pieces printed for J. Davies, London,* 1774.

13 Objections answered.

All this is true; but we apprehend it is not to the purpose. Mr Locke has no where expressed himself in such a manner as to lead us to suppose that he believed the soul to be extended or coloured; or, when it begins to think, incapable of energy, and wholly unfurnished with ideas: but he certainly did believe, that it begins not to think the first instant of its existence, and that it *acquires* all the ideas of which it is ever possessed. We may undoubtedly write upon a piece of white paper that sugar is bitter, and that wormwood is sweet; but how the capacity of paper to receive the symbols of false propositions should make Mr Locke's comparison improper or dangerous, we cannot comprehend. Mr Usher indeed says, that it is improper on this account, "that no human art or industry is able to make those impressions upon the mind: in respect of them, the mind discovers not a passive capacity, but resists them with the force of fate." Does it indeed? does the mind reject the idea of sugar or of bitterness, of contempt or of indifference? May not any man have the *idea* of sugar and at the same time the *idea* of bitterness, and compare the one with the other in his mind, as well as the word *sugar* may be written beside the word *bitter*, and connected with it on the same piece of paper? In all this we perceive nothing that is impossible or even difficult. The mind cannot indeed be made to feel that sugar has the same taste with wormwood; but who ever thought that it could? Not Mr Locke, we shall be bold to say; nor does his simile give the smallest countenance to such an absurdity. The author of the Essay on the Human Understanding understood his subject too well to imagine that either truth or falsehood could be communicated to paper, or that paper is capable of comparing ideas. Paper is capable of receiving nothing but lines or figures; and it passively receives whatever lines or figures we may choose to inscribe on it: yet if a pen be carried over it in a circular direction, the figure impressed will not be a square; just as, to the mind of one eating sugar, the taste communicated is not that of wormwood.

On a piece of paper a circle may be described, and close beside it a square: in like manner an agreeable sensation may be communicated to the mind, and immediately afterwards a sensation that is disagreeable. These two sensations, or the ideas which they leave behind them, may be compared together; and it is certainly true that no art or industry can make them appear similar in the mind: but is it not equally true, that no art or industry can make the circle and the square similar on the paper? The paper is susceptible of any sort of plain figures, and the mind is equally susceptible of any sort of ideas or sensations; but figures dissimilar cannot be made to coincide, neither can discordant ideas be made to agree. Again, one may write upon paper, that "a circle *is* a square," and likewise that "a circle *is not* a square;" and both these propositions may be communicated to the mind by the organs of sight or of hearing. The paper receives the *words* expressive of the false as well as those expressive of the true proposition; and the mind receives the *ideas* and *relations* signified by the one cluster of words as well as those signified by the other: but in the mind the *idea* of a square is *different* from that of a circle, and on the paper the *figure* of a square is *different* from the *figure* of a circle. The great difference between the mind and the paper is, that *the former* is *conscious* of its ideas, and *perceives* their agreement or disagreement; whereas the paper is *not* conscious of the figures drawn upon it, nor perceives any thing about them. But still those figures are what they are; they either agree or disagree on the paper, as well as the ideas either agree or disagree in the mind. It is not in the power of the mind to alter the *ideas* of the square and the circle, nor in the power of the paper to alter the *forms* of these figures.

It appears then, that the principles of Mr Locke, and the comparison by which he illustrates them, have no more tendency to subvert the difference between truth and falsehood, right and wrong, than the passiveness of paper has to subvert the difference between a straight line and a crooked, a circle and a square: and with a view to establish the doctrine of innate ideas and instinctive principles of knowledge, we might with as much propriety ask, Whether it be possible to imagine that any mode of manufacture could make paper of such a nature, as that a pen drawn over it in a circular direction would leave the figure of a square? as that, "Whether it be possible to imagine, that any course of education could ever bring a rational creature to believe that two and two are equal to three."

The

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The mind being thus, as we may say, originally white paper, void of all characters, without ideas or notions of any kind, the first question which we have to consider is, Whence and in what manner it derives the materials of all its knowledge? To this question the only answer which can be given is, That it derives them from observation and experience; from observation, either employed upon external objects of sense, or turned inwardly upon its own operations. Our senses, conversant about particular external objects, convey into the mind several distinct perceptions; such as those of *colour*, *figure*, *heat*, *cold*, *bitterness*, *sweetness*, and all those things which are usually called *sensible qualities*. The notions, ideas, or whatever else they may be called which are acquired in this manner, may be called *sensible knowledge;* and the source of that knowledge is termed *sensation*.

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The other fountain from which experience furnishes the understanding with knowledge, is that attention which we are capable of giving to the operations of our own minds when employed about those ideas which were originally suggested by objects of sense. These operations, when the soul comes to reflect on them, furnish us with a set of notions entirely different from the ideas of sense; such as the notions of *perception*, *thinking*, *doubting*, *believing*, *reasoning*, *knowing*, *willing*, and all the different energies and passions of our own minds. Of these operations we are always conscious when we are awake: but it requires, as shall be shown afterwards, no inconsiderable effort to set them, as it were, at a distance, to reflect on them and consider what they are; but when we have made this effort, we acquire notions as distinct, and perhaps more important, than those ideas which we receive through the medium of the senses.

Sensation and reflection then furnish mankind with the first materials of all their knowledge. The mind seems not to have ideas or notions of any kind which it did not receive by one or other of these ways. By means of the senses it perceives external objects; and by that power which it has of turning its attention upon itself, it discovers the nature and manner of its own operations.

Although the knowledge which we acquire from *reflection* be of equal importance, and perhaps of greater certainty than that which we receive through the medium of the senses, it comes into the mind at a much later period; both because it is impossible that the faculties of the mind should operate without materials, and because it is much more difficult to attend to these operations even while they are going on, than to the objects of sense which solicit our attention. It is for this reason pretty late before children have any notions whatever of the operations of their own minds; and of the greater part of these operations the bulk of mankind have no clear or accurate notions during their whole lives. On the other hand, every human being is so surrounded with bodies, which perpetually and variously affect his senses, that a variety of sensible ideas force an entrance even into the minds of children. In order therefore to trace the procedure of the understanding, and to ascertain the extent and limits of human knowledge, it should seem that we must begin with considering the external senses, that we may discover the manner in which we receive knowledge by means of them, the objects of that knowledge, and its certainty. It is to be observed, however, that though we consider the mind as possessed of many powers or faculties, and inquire first into the nature of that faculty which we conceive to be first exerted, this is done merely for the sake of proceeding in our subject with method and perspicuity. The mind is one simple and undivided being; and in every mental energy it is the whole mind, and not any part or portion of it, that is energetic. On this account, it is impossible to explain even the nature of sensation and perception to him who knows not what is meant by *will* or *understanding;* but to every one who is acquainted with the common import of these words, and who has read the short system of Logic inserted in this Work, we hope that our theory of perception will be intelligible and convincing.

Of Sensation.

Chap. I. *Of* Sensation *and* Perception.

Sect. I. *Of Sensation.*

15 Sensation by five organs.

The Supreme Being, who made us and placed us in this world, has given us such powers of mind as he saw to be suited to our state and rank in his creation. He has given us the power of perceiving many objects around us; but that power is limited in various ways; and particularly in this, that without the organs of the several senses we perceive no external object. The senses, as every one knows, are five in number, and each communicates its proper sensation. It is by the eyes alone that we see, by the ears that we hear, by the nose that we smell, and by the tongue and palate that we taste; the sense of feeling or touch is spread over the whole body, for we feel equally by our hands and by our feet, &c. To the powers of perception by the senses it is necessary not only that we have all the organs enumerated, but that we have them also in a sound and natural state. There are many disorders of the eye which cause total blindness, as well as others which impair without destroying the power of vision. The same thing is true of the organs of all the other senses.

All this is so well known from experience, that it needs no proof; but it may be worth while to observe, that it is known from experience only*. For any thing that we know to the contrary, our Creator might have endowed us with the power of perception by a thousand organs of sense, all different from those which we possess; and it is certain that he himself perceives every thing more perfectly than we do without bodily organs.

16 These organs themselves not sentient, but

For it is to be observed, that the organs of sense are different from the being which is sentient.—It is not the eye which sees, nor the ear which hears; these are only the organs by which we see and hear. A man cannot see the satellites of Jupiter but by means of a telescope, nor hear a low voice but by means of an ear trumpet. Does he from this conclude that it is the telescope which sees those satellites, or the trumpet which hears that voice? Such a conclusion would be evidently absurd. It is no less absurd to conclude that it is the eye which sees, or the ear which hears. The telescope and the trumpet are artificial organs of sight and of hearing, of which the eye and the ear are natural organs; but the natural organs see and hear as little as the artificial.

17 Instruments of sensation.

That this is the case with respect to the eye and the ear,

* *Reid's Essays on the Intellectual Powers of Man.*

Of Sensation.

ear, is so obvious, that, as far as we know, it has never been denied. But with respect to the senses of touch, taste, and smell, the truth at first view appears not so evident. A celebrated writer has observed*, that "after the utmost efforts, we find it beyond our power to conceive the flavour of a rose to exist in the mind: we are necessarily led to conceive that pleasure as existing in the nostrils, along with the impression made by the rose upon that organ (c); and the same will be the result of experiments with respect to every feeling of taste, touch, and smell. Touch (he says), affords the most satisfactory evidence, and philosophy detects the delusion." To detect this delusion requires, indeed, no great depth in philosophy; for it is so far from being true that we are necessarily led otherwise than by association, of which the laws shall be explained afterwards, to conceive the pleasure or pain of touch as existing at that part of our body upon which the impression is made, that as every man must have observed, children previous to experience cannot distinguish the precise place of their bodies which is affected by the touch of any external object. Nay, we believe it will be found upon trial, that if a full grown man, with all the experience of age to guide him, be pricked with a pin on any part of his body which he has seldom handled, and never seen, he will not readily nor at first put his finger upon the wound, nor even come very *near* to the wound. This, however, he would certainly and infallibly do were the sense of touch necessarily conceived as existing at the organ. To these observations objections may perhaps be made, which we cannot stay to obviate; but the following, we think, will admit of none. We appeal to every man who has experienced that particular sensation of touch which Scaliger dignified with the name of a sixth sense, whether, whilst those sensations were new to him, he was necessarily led to conceive them as existing at any particular organ. If he was not, it follows undeniably that the organs of sensation are different from the being which is sentient; that it is not the eye which sees, the ear which hears, the nostrils which smell, the tongue which tastes, nor any part of the body which feels; and that it is by experience that we learn to associate our several sensations with those organs upon which the impressions are made.

* *Elements of Criticism.*

It is, however, certain that we receive no sensation from external objects, unless when some impression is made upon the organ of sense, either by the immediate application of the object itself, or by some medium which passes between the object and the organ †. In two of our senses, viz. *touch* and *taste*, there must be an immediate application of the object to the organ. In the other three the sensation is occasioned by the impression of some medium passing from the object to the organ. The effluvia of bodies drawn into the nostrils with the breath are the medium of smell; the undulations of the air are the medium of hearing; and the rays of light passing from visible objects to the eye are the medium of sight. These are facts known from experience to hold universally both in men and in brutes. It is likewise a law of our nature perfectly known to all who know any thing of anatomy, that in order to actual sensation the impressions made upon the external organs must be communicated to the nerves, and from them to the brain. First, The object, either immediately, or by some medium, makes an impression upon the organ; the organ serves only as a medium, by which the impression is communicated to the nerves; and the nerves serve as a medium to carry it on to the brain. Here the corporeal part ends; at least we can trace it no farther. The rest is all intellectual.

† *Reid's Essays on the Intellectual Powers of Man, and Hartley's Observations on Man.*

18 The brain and nerves necessary to sensation.

The proof of these impressions upon the nerves and brain in sensation is this, that from many observations and experiments it is found, that when the organ of any sense is perfectly sound, and has the impression made upon it by the object ever so strongly, yet if the nerve which serves that organ be cut or tied hard, there is no sensation; and it is well known that disorders in the brain deprive us of sensation, while both the organ and its nerve are sound.

19 Process of nature in sensation.

There is sufficient reason, therefore, to conclude, that in sensation the object produces some change in the organ; that from the organ the change proceeds to the nerve, and from the nerve to the brain. Hence it is that we have positive sensations, from negative objects, or mere nonentities, such as *darkness*, *blackness*, and *vacuity*. For, sensation resulting from changes in the brain, whatever produces any change must of course occasion a new sensation: but it is obvious, that the mere absence of any impression, by the removal of the object which produced it, must as necessarily cause a change in the organ, nerves, and brain, as the presence of a new impression from a new object. To these changes, or that which *immediately* produces them, we give the name of *impressions;* because we know not how, in a general manner, to express more properly any change produced by an external cause without specifying the nature of that cause. Whether it be pressure, or attraction, or repulsion, or vibration, or something unknown, for which we have no name, still it may be called an impression.

Sir Isaac Newton was perhaps the first who supposed that the rays of light falling upon the bottom of the eye excite vibrations in the *tunica retina;* and that those vibrations being propagated along the solid fibres of the optic nerves into the brain, cause the actual sensation of seeing. This hypothesis was adopted by Dr Hartley, applied to the other senses, and shown to be

(c) Another eminent writer thinks on this subject very differently, and in our opinion much more justly.—"Suppose (says Dr Reid) a person who never had this sense (viz. *smell*) before, to receive it all at once, and to smell a rose; can he perceive any similitude or agreement between the smell and the rose? or indeed between it and any other object whatever? Certainly he cannot. He finds himself affected in a new way, he knows not why, or from what cause. He is conscious that he is not the cause of it himself; but he cannot from the nature of the thing determine whether it be caused by body or spirit; by something near, or by something at a distance. He cannot give it a *place* any more than he can give a place to melancholy or joy; nor can he conceive it to have any existence but when it is smelled." *Inquiry into the Human Mind*, ch. 2. sect. 2.

f Pe ption.

be at least as probable as any which has yet been invented to account for the perception of external objects by means of the organs of sense. Be this as it may, experience informs us, that whatever be the nature of those impressions and changes which are made by external objects upon the senses, nerves, and brain, we have without them no actual sensation, and of course perceive nothing *ab extra*. Hence it has been supposed, that the mind is wholly passive in sensation, and that sensation is *necessarily* produced by those impressions. But this we believe to be a mistake. Every man who has been attentive to his own thoughts and actions, must know instances of impressions having been certainly made upon his organs of sense without producing any sensation, or suggesting to his mind the perception of the particular objects by which the impressions were caused. He whose mind is intensely employed in any particular pursuit, may have his eyes open upon an object which he does not see; or he may not hear the sound of a clock striking within two yards of him: Nay, we will venture to affirm, that there is hardly one reader of this article to whom such absences of sensation have not often occurred. Now, as there is no reason to suppose, that in the one case the undulations of the air, caused by the striking of the clock, did not reach his ears, or that in the other the rays of light, reflected from the object, did not fall upon his eyes, which were open to receive them; the only reason which can be assigned for his not having, in these instances, had audible and visible sensations, is, that his mind was so engaged in something else as not to pay to the vibrations in his brain that attention, if we may so say, without which impressions *ab extra* can produce no sensation. There are, indeed, some impressions on the organs of sense so violent and so sudden, as to force themselves upon the mind however employed. Such are those made on the ear by thunder, and on the eye by strong light. In these cases, sensation is involuntary and unavoidable; whence we conclude, not that in such instances the mind is passive or destitute of energy, but that by the violent agitation given to the brain, it is roused from its reverie, and compelled to give attention. It appears, therefore, that in sensation the mind exerts some kind of energy; for in nothing but in the sentient being itself can we seek for the cause why, when all external circumstances are the same, organical impressions sometimes produce sensations and sometimes not; and that cause can only be the energy of the mind; what kind of energy we pretend not to say.

Sect. II. *Of Perception by the Senses.*

How the correspondence is carried on between the thinking principle within us and the material world without us, has always, as Dr Reid observes, been found a very difficult problem to those philosophers who consider themselves as obliged to account for every phenomenon in nature. It is, indeed, a problem of which we expect not to see a complete solution. A few steps beyond the vulgar we may certainly go; but the nature of that connexion by which the mind and body are united, will probably remain for ever unknown. One question, however, which has employed much of the attention of philosophers, both ancient and modern, appears to be not wholly unanswerable. It is, Whether by means of our senses we perceive external objects mediately or immediately; or in other words, Whether sensation and perception be one and the same thing, or two things succeeding each other? On this subject, till of late, there appears to have been in the main a great uniformity in the sentiments of philosophers, notwithstanding their variations respecting particular points. Of some of the most eminent of them, we shall give the opinions as we find them collected by one * who is well acquainted with their writings, who is thoroughly qualified to estimate their respective merits, and who cannot be suspected of partiality to that theory which we feel ourselves compelled to adopt.

Of Perception.

* Dr Reid in his *Essays on the Intellectual Powers of Man.*

22 The hypothesis of Plato;

"Plato illustrates our manner of perceiving external objects thus: He supposes a dark subterraneous cave, in which men lie bound in such a manner as that they can direct their eyes only to one part of the cave. Far behind there is a light, of which some rays come over a wall to that part of the cave which is before the eyes of our prisoners. A number of men variously employed pass between them and the light, whose shadows are seen by the prisoners, but not their persons themselves. In this manner did that philosopher conceive that by our senses we perceive not things themselves, but only the shadows of things; and he seems to have borrowed his notions on this subject from the disciples of Pythagoras.

23 Of Aristotle;

"If we make due allowance for Plato's allegorical genius, his sentiments with respect to sensation and perception correspond very well with those of the Peripatetics. Aristotle, the founder of that school, seems to have thought, that the soul consists of two or three parts, or rather that we have three souls—the vegetable, the animal, and the rational. The animal soul is held to be a certain *form* of the body, which is inseparable from it, and perishes at death. To this soul the senses belong; and he defines a sense to be that which is capable of receiving the sensible forms, or species of objects, without any of the matter of them; as wax receives the form of the seal without any of its matter. Of this doctrine it seems to be a necessary consequence, that bodies are constantly sending forth, in all directions, as many different kinds of forms without matter as they have different sensible qualities. This was accordingly maintained by the followers of Aristotle, though not, as far as we know, taught by himself. They disputed concerning the nature of these forms or species, whether they were real beings or nonentities: but of matter and form we shall have occasion to speak afterwards.

24 Of Des Cartes;

"After Aristotle had kept possession of the schools for more than a thousand years, his authority, which had often supplied the place of argument, was called in question by Lord Bacon and others. Des Cartes, however, was the first philosopher who, convinced of the defects of the prevailing system, attempted to form another entirely new: but on the nature of perception by means of the senses he differs little or nothing from those who had preceded him in that department of science. He denies, indeed, and refutes by solid reasoning, the doctrine which maintains that *images*, *species*, or *forms* of external objects, come from the objects themselves, and enter into the mind by the avenues

avenues of the senses. But he takes it for granted, as all the old philosophers had done, that what we immediately perceive must be either in the mind itself, or in the brain, in which the mind is immediately present. The impressions made upon our organs, nerves, and brain, can be nothing, according to his philosophy, but various modifications of extension, figure, and motion. There can be nothing in the brain like *sound* or *colour*, *taste* or *smell*, *heat* or *cold*. There are sensations in the mind, which by the laws of the union of the soul and body, are raised on occasion of certain traces in the brain; and although he sometimes gives the name of ideas to these traces, he does not think it necessary that they should be perfectly like the things which they represent, any more than that words and signs should resemble the things which they signify.

"According to this system it would appear, that we perceive not external objects *directly* by means of our senses; but that these objects, operating either mediately or immediately upon the organs of sense, and they again upon our nerves and brain, excite in the mind certain sensations; whence we *infer* the existence of external objects from our sensations of which they are the cause. Perception of external objects, therefore, according to Des Cartes, is not one simple original act of the mind, but may be resolved into a process of reasoning from effects to causes."

25 Of Malebranche.

The doctrines of Malebranche, Locke, and Hartley, respecting perception, differ not essentially from that of Des Cartes. Malebranche, indeed, supposes, that external objects are not themselves the causes of perceptions; but that the Deity, being always present to our minds more intimately than any other being, does, upon occasion of the impressions made upon our organs of sense, discover to us, as far as he thinks proper, and according to fixed laws, his own ideas of the object: and thus, according to him, we see all things in God, or in the divine ideas. He agrees, however, with Des Cartes and the ancient philosophers, in considering it as a truth which it is impossible to refute, that we perceive not the objects without us, the sun, moon, and stars, &c. because it is not likely that the soul sallies out of the body, and takes a walk, as it were, through the heavens to contemplate these objects. She sees them not therefore by themselves; and the immediate object of the mind, when it sees the sun, is not the sun itself, but something which is intimately united to the mind, and is that which he calls an *idea*.

26 Of Locke.

Locke, speaking of the reality of our knowledge, says: "It is evident the mind knows not things immediately, but only by the intervention of the *ideas* it has of them. Our knowledge, therefore, according to him, is real only so far as there is a conformity between our ideas and the things which they represent." The manner of our perceiving external objects he illustrates by the following similitude: "Methinks the understanding is not much unlike a closet wholly shut from light, with only some little opening left, to let in external visible resemblances or ideas of things without. Would the pictures coming into such a dark room but stay there, and lie so orderly as to be found upon occasion, it would very much resemble the understanding of a man in reference to all objects of sight, and the ideas of them *." He has elsewhere † defined an *idea* thus: "Whatsoever the mind perceives in itself, or is the immediate object of perception, thought, or understanding, that I call an *idea*; and the power to produce any idea in our mind, I call *quality* of the subject wherein the power is." He likewise thinks it "easy to draw this observation, that the ideas of what he calls primary qualities of bodies, viz. *extension*, *solidity*, *figure*, *mobility*, &c. are resemblances of these qualities as they really exist in the bodies themselves.

* Essay on the Understanding, book ii. chap. 11.

† Book ii. chap. 8.

This unguarded expression, which affirms that ideas in the mind are the resemblances of external things, has brought upon Mr Locke much undeserved ridicule. That on this and other occasions he uses the word *idea* with too great latitude, and that he often confounds ideas with sensations, and even with the causes of sensation, must be admitted by his warmest admirers: but we believe, that by an attentive reader, who peruses his whole work, and compares such passages as are obscure with those which are clearer, his meaning may always be discovered, and with respect to sensation and perception will generally be found just. That by calling the ideas of primary qualities resemblances of the qualities themselves, he meant nothing more than that bodies in all possible states impress the senses, nerves, and brain, in such a manner as to produce in the mind certain sensations, between which and those impressions there is an inseparable, though unknown, connection, is evident from the account which he gives of the manner of perception. "Our senses (says he), conversant about particular sensible objects, do convey into the mind several distinct perceptions of things according to those various ways in which these objects affect them: and thus we come by those ideas we have of *yellow*, *white*, *heat*, *cold*, *soft*, *hard*, *bitter*, *sweet*, and all those which we call sensible qualities; which when I say the senses convey into the mind, I mean, they from external objects convey into the mind what produces those perceptions." And as bodies can act only by impulse, he adds, that "those perceptions can be produced only by an impression made upon the senses, and some motion thence continued by our nerves to the brain or seat of perception."

27 Of Hartley.

Dr Hartley was the pupil of Locke and Newton; and has, in a more satisfactory manner than all who had preceded or have since followed him, explained the material part of the process of perception. His principles we shall have occasion, during the course of the article, to develope pretty fully. For our present purpose it is sufficient to say, that all his observations and arguments evidently suppose, that nothing distant from the mind can be perceived in the immediate act of sensation; but that the apparently immediate perception of external objects is an instance of early and deep-rooted association.

28 Of Hume.

In this sentiment Mr Hume agrees with his predecessors; but he obscures his philosophy, and misleads his reader, by confounding sensations with the impressions from which they proceed. "Every one (says he†) will allow, that there is a considerable difference between the perceptions of the mind, when a man feels the pain of excessive heat, or the pleasure of moderate warmth, and when he afterwards recals to his memory this sensation, or anticipates it by his imagination."

† Inquiry concerning Human Understanding, sect.

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tion." The less forcible and lively of these perceptions he with great propriety calls *ideas*; but it is either through wilful perverseness, or confusion of intellect, that he chooses to call the others *impressions.* Sensation and perception are caused by *impressions*; but they are no more impressions themselves, than the pain occasioned by the stroke of a bludgeon is the stroke itself, or the bludgeon with which it was struck. But more of this afterwards.

9
Agreement of philosophers, and the reason of it.

† Mosheim's edition of Cudworth's Intellectual System, where the opinions of the philosophers of antiquity are most faithfully collected than in any other work with which we are acquainted.

Thus far, then, that we perceive not external objects *directly*, but infer their existence from certain sensations excited in our minds by the operation of these objects upon our *senses*, *nerves*, and *brain*, seems to have been the opinion of every philosopher from Pythagoras † to Mr Hume. For an opinion so universal, and at the same time so contrary to the persuasion of the multitude, some cogent reason must have been assigned. That reason has been given by many philosophers, but by none with greater perspicuity than Dr Porterfield, in his Essay concerning the Motion of the Eyes. "How body acts upon the mind, or mind upon body (says he), I know not; but this I am very certain of, that nothing can act, or be acted upon, where it is not: and therefore our mind can never perceive any thing but its own proper modifications, and the various states of the sensorium to which it is present. So that it is not the external sun and moon, which are in the heavens, that our mind perceives, but only their image or representation impressed on the sensorium. How the soul of a seeing man sees those images, or how it receives those ideas from such agitations in the sensorium, I know not; but I am sure it can never perceive the external bodies themselves to which it is not present."

This reasoning appears to have force; and, perhaps, the unanimous agreement of thinking men in all ages has still greater force; yet the doctrine which prevailed so long, and which to Locke appeared so evident as to need no proof, has been since called in question by some eminent philosophers in our own country; who, though they allow that we cannot perceive external objects but by means of the senses, yet affirm that they are the objects themselves which we perceive directly; and that in perception there is no association which can be resolved into a process of reasoning from sensations the effects, to external objects the causes. Dr Reid, who was perhaps the first, and is unquestionably the ablest of this class of philosophers, had expressed himself on the subject as follows:

"If we attend to the ACT of our mind, which we call the perception of an external object of sense, we shall find in it these three things: *First*, Some conception or notion of the object perceived. *Secondly*, A strong and irresistible conviction and belief of its present existence. And, *Thirdly*, That this conviction and belief are immediate, and not the effect of reasoning ‡." To the first and second of these propositions, we are persuaded that Des Cartes and Locke would readily have assented; nor do we imagine that they would have denied the third, had the author allowed that this strong and irresistible conviction is the consequence of an early and deep-rooted association resolvable into a process of reasoning. This, however, the learned professor does not allow; for he repeatedly affirms, that it is instinctive and original, and that "the constitution of our power of perception determines us to hold the existence of what we distinctly perceive as a first principle, from which other truths may be deduced, but it is deduced from none." With this view of the matter, he could with no propriety attempt to support his own opinion by argument; but to the reasonings of Dr Porterfield and others in defence of the Cartesian theory, he replies in the following words: "That nothing can act immediately where it is not, I think must be admitted (D); for I agree with Sir Isaac Newton, that power without substance is inconceivable. It is a consequence of this, that nothing can be acted upon immediately where the agent is not present; let this, therefore, be granted. To make the reasoning conclusive, it is farther necessary, that when we perceive objects, either they act upon us, or we act upon them. This does not appear self-evident, nor have I ever met with any proof of it †."

‡ *Essays on the Intellectual Powers of Man*, Essay ii. ch. 5.

Of the profundity of Dr Reid's understanding, we have the most firm conviction; nor is there any metaphysician, ancient or modern, from whom we differ with greater reluctance: but we cannot help thinking this a very rash assertion, as his own works appear to us to afford complete proofs that, in perception, the mind both acts and is acted upon. Let us attend, however, to the reasons which, on this occasion, induced

† *Essays on the Intellectual Powers of Man*, Essay ii. chap. 14.

(D) One of the most celebrated of Dr Reid's followers thinks otherwise. "That no distant subject can act upon the mind, is a proposition (says Lord Kames) which undoubtedly requires evidence; for it is not instinctively certain: And, therefore, till the proposition be demonstrated, every man may without scruple rely upon the conviction of his senses, that he hears and sees things at a distance." But his Lordship ought to have known, that Locke and Berkeley, the two philosophers whom he was combating, have nowhere called in question the conviction of their senses. They do not, indeed, admit, that the external organs are themselves percipient, or that by means of them the mind can *immediately* perceive distant objects; but they have no where denied, that through the *medium* of them the mind comes to the knowledge of external existence. And the reasons which they assign for this twofold opinion are, that in perception they experience action or the effects of action, which is not their own; and that it is an intuitive truth, that nothing can act where it is not present. "But admitting (says his Lordship) that no being can act but where it is, is there any thing more simple or more common, than the acting upon subjects at a distance by intermediate means? This holds in fact with respect both to seeing and hearing." It certainly does, and with respect to the other senses likewise; but it is the very thing for which Locke and Berkeley would have contended, had any man in their days presumed to call it in question. It is the very foundation of their system; and if it be granted, nothing can be more evident, than that external existence is not the *immediate* object of perception. See *Appendix to Elements of Criticism.*

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ced him to think, that in perception there is no action either of the object on the mind or of the mind on the object.

"When we say, that one being acts upon another, we mean, that some power or force is exerted by the agent which produces, or has a tendency to produce, a change in the thing acted upon. If this be the meaning of the phrase, as I conceive it is, there appears no reason for asserting, that in perception, either the object acts upon the mind or the mind upon the object. An object, in being perceived, does not act at all. I perceive the walls of the room where I sit; but they are perfectly inactive, and therefore act not upon the mind. To be perceived, is what logicians call an external denomination, which implies neither action nor quality in the object perceived."

30 We think unsuccessfully; and

This last sentence we pretend not to understand. Substance without qualities is to us inconceivable, and certainly is no object of perception; for Dr Reid himself has told us, and told us truly, that "the objects of perception are the various qualities of bodies." That an object in being perceived does not act at all, is directly contrary to what the ingenious author has taught us, both in his *Inquiry* and in his *Essays*, viz. that "it is a law of our nature that we perceive not external objects, unless certain impressions be made by the object upon the organ, and by means of the organ upon the nerve and brain;" for if the external object in being perceived make impressions, it is certainly not true that it acts not at all. It is indeed readily acknowledged, that when one perceives the walls of the room where he sits, these walls do not act immediately upon the organs of sight; but it does not, therefore, follow, that they are perfectly inactive; for it is known to all mankind, that from every point of the wall which is seen, rays of light are reflected to the eye; that those rays make upon the *retina tunica* an impression, which is conveyed by the optic nerve to the brain; and that this impression on the brain is one of the immediate causes of vision. In what *particular manner* it causes vision, we shall never be able to discover, till we know more of the laws which unite mind and body, and by which one of these is qualified to act upon the other; but because we know not the *manner* of this operation, to affirm that there is no operation at all seems to be as absurd as it would be to affirm, because we perceive no necessary connexion between a stroke and the sensation of sound, that the sound of a musical string is not caused by the stroke of a plectrum. That God might have given us powers of perception of a different kind from those which we possess, there can be no doubt; but with what we might have been, we have no concern. As we are, we know perfectly that the eye is an instrument of vision, because without it nothing can be seen: we know also that the retina and optic nerves are equally necessary; because if they be disordered, vision is still wanting; we know likewise, that the brain is necessary to all perception: because, when it is disordered, thinking either entirely ceases, or is proportionably disturbed. And, lastly, We are not more certain of our own existence, than that *actual perception* takes not place but when the object makes an impression upon some organ of sense; for when no rays of light fall upon the eye, we see nothing; when no sapid body is applied to the tongue and palate, we taste nothing; and if we could be removed from every thing solid, we would feel nothing. These are conclusions which cannot be controverted. They are admitted equally by the philosopher and by the plain unlettered man of common sense; nor are they rendered one whit less certain by our not being able to go a step farther, so as to discover in what *manner* the brain or the affections of it can be the immediate instrument of sensation and perception. For (as Dr Reid, in the spirit of true philosophy, observes ‡), in the operation of mind, as well as in those of bodies, we must often be satisfied with knowing that certain things are connected and invariably follow one another, without being able to discover the chain that goes between them. It is to such connexions that we give the name of *laws of nature;* and when we say that one thing produces another by a law of nature, this signifies no more than that one thing which we call in popular language *the cause*, is constantly and invariably followed by another which we call *the effect;* and that we know not *how* they are connected.

‡ *Inquiry into the Human Mind*, 4th edit. p. 258.

In the preceding section we have observed, that in sensation the mind exerts some energy; and therefore, as on every hypothesis perception is a consequence of sensation, it follows, that in perception the mind cannot be wholly inactive. Dr Reid, in his Essays on the Intellectual Powers of Man, seems to affirm that it is. "I see no reason (says he) to believe, that in perception the mind acts upon the object. To perceive an object is one thing, to act upon it is another: Nor is the last at all included in the first. To say that I act upon the wall by looking at it, is an abuse of language, and has no meaning." This is indeed true; it would be a great abuse of language to say, that by looking at the wall a man acts upon it: but we do not believe that any man ever said or supposed such a thing. The philosophers, whose opinion he is combating, might argue in this manner. We are conscious that in perception the mind is active; nothing can act immediately where it is not; the mind cannot act immediately upon external existence: external existence therefore is not the immediate object of that energy which is exerted in perception. As Dr Reid affirms that external existence is the immediate object of perception, he must deny the first proposition in this argument; for *if it* be granted, as we have just seen that in his reply to Dr Porterfield he admits the second, the laws of reasoning will compel him to admit the third. To say, that in perception the mind acts not upon *external* objects, is a truth in which all mankind are agreed; and it is the very principle from which his antagonists infer, that the conviction of the present existence of external objects is not an original and instinctive consequence of sensation, but an early and deep-rooted association which may be resolved into a process of reasoning. His meaning, therefore, must be, that in perception the mind *acts not at all:* but this is directly contrary to his definition of perception, which he calls an ACT of the mind: it is likewise contrary to his theory of perception, as it is detailed in *the Inquiry into the Human Mind on the principles of Common Sense.* We are there taught, with equal elegance and perspicuity, "that an impression made by an external object upon the organ, nerves, and brain, is

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is followed by a *sensation*, and that this sensation is followed by the perception of the object." We are likewise taught, that "although the Peripatetics had no good reason to suppose an active and passive intellect, they yet came nearer the truth, in holding the mind to be, in sensation, partly passive and partly active, than the moderns in affirming it to be purely passive. Sensation, imagination, memory, and judgment, have by the vulgar, in all ages, been considered as acts of the mind. The manner in which they are expressed in all languages shows this: for when the mind is much employed in them, we say, it is very active; whereas, if they were impressions only, we ought to say that the mind is very passive." All this is undeniable; but if sensation necessarily precede perception, and if in sensation the mind be active, what becomes of the assertion, that in perception it acts not at all? Indeed we may appeal to the common sense of mankind, whether any thing can be perceived without some mental energy of the percipient. For when the impressions made on the external senses are faint, in order to be conscious of them an evident exertion is requisite, not of the organ only, but also of the mind, as in perceiving very remote objects and sounds; but when the impressions are stronger, the perception is involuntary and unavoidable, as has been already explained in the preceding section.

31 T[here]fore th[e] [an]d the... [per]cep[ti]on to be [r]efer[red] to this.

It being thus certain that in perception the mind both acts and is acted upon, and it being universally acknowledged that nothing can act where it is not, we feel ourselves compelled to admit with the Cartesians, that in perception the conviction of the present existence of external objects is not original and instinctive, but the consequence of an early and unavoidable association of certain sensations with the causes which produce them. In this opinion we are still more confirmed by the well-known fact, that particular pressures upon the organ, nerves, and brain, excite not only sensations, but even perceptions of objects apparently external, when no such objects are within the reach of our senses. Thus §, if a man in the dark press either corner of his eye with his finger, he will see a circle of colours like those in the feather of a peacock's tail, though no such external object be before him, and though the room be so dark that nothing external could possibly be seen. Again, if a burning coal be nimbly moved round in a circle, with gyrations continually repeated, the whole circumference of the circle will at once appear on fire, though it is certain that there can really be no fire but one portion of that circumference, equal in length to the diameter of the coal. These are facts known to all mankind; and they are perfectly irreconcileable with the supposition, that the perception of external objects by the sense of sight is original and instinctive; but they are at once accounted for, if it be true that rays of light falling from external objects upon the *retina tunica* agitate the optic nerves and brain, and that such agitations excite sensations in the mind which experience has taught us to refer to external objects, as, under God, their ultimate cause.

§ [Har]tley's O[bser]va[ti]on.

But although we have declared ourselves to be in this instance Cartesians, we do not admit all the absurdities which have sometimes been imputed to that system of perception. We do not believe that external objects are perceived by means of images of them in the mind or the brain; nor do we think that Des Cartes or Locke has any where affirmed that they are, otherwise than by an expression obviously figurative, denoting, not that the actual shapes of things are delineated in the brain or upon the mind, but only that impressions of some kind or other are conveyed to the brain by means of the organs of sense and their corresponding nerves; and that between these impressions and the sensations excited in the mind, there is a real, and in our present state a necessary, though unknown, connexion.

32 That theory fairly stated, and

Upon the whole, we think that there is good evidence for believing, that in perception the process of nature is as follows: *First*, If the object be not in contact with the organ of sense, there must be some medium which passes between them; as, in vision, the rays of light; in hearing, the vibrations of elastic air; and in smelling, the effluvia of the body smelled; otherwise we have neither sensation nor perception. *Secondly*, There must be some action or impression upon the organ of sense, either by the immediate application of the object, as in the two senses of touch and taste; or by the medium that goes between them, as in the other three senses. *Thirdly*, The nerves which go from the brain to the organ, must receive some impression by means of that which was made upon the organ; and by means of these nerves that impression must be carried to the brain. *Fourthly*, The impression made upon the organs, nerves, and brain, rouses the dormant energy of the mind; and this double action of the mind and the object produces a sensation. And, *lastly*, As we know by experience that the mind alone cannot, by any exertion of its own, produce one sensation, and are intuitively certain that nothing can begin to exist without a cause, we infer from the existence of any new sensation the existence of some other cause than the internal energy of the mind from which that sensation proceeds; and this cause experience teaches us to be the external object. This process is carried on so rapidly, and the several parts of it, by being continually repeated, are so closely associated, that except by a reflex act of the mind we distinguish them not from one another, and therefore we denominate the whole *perception*.

33 Shown to differ little from Dr Reid's.

It is with extreme diffidence that we advance a doctrine which Dr Reid has controverted; but he differs from us only in the last stage § of the process, where he supposes sensation and perception to be two simple and independent acts of the mind. Yet he sometimes expresses himself, as if he thought, as we do, that in perception the belief of the present existence of external objects is rather the result of experience, than an instinctive persuasion. Thus, speaking of the perception which we have in smelling a rose, he says §, "Perception has always an external object, and the object of my perception in this case is that quality in the rose which I discern by the sense of smell. Observing that the agreeable sensation is raised when the rose is near, and ceases when it is removed, I am led by my nature [we think *by experience* would have been more proper] to conclude some quality to be in the rose, which is the cause of this sensation. This quality in the rose is the object perceived; and that act of my mind, by which I have the conviction and belief

§ See *Inquiry into the Human Mind*, 4th edit. p. 383.

§ *Essays on the Intellectual Powers of Man*, Essay ii. chap. 15. and 21.

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lief of this quality, is what in this case I call perception. Again (he says) that "three of our senses, viz. smell, taste, and hearing, originally gives us only certain sensations, and a conviction that these sensations are occasioned by some external object. We give a name to that quality of the object by which it is fitted to produce such a sensation, and connect that quality with the object and with its other qualities. Thus we learn, that a certain sensation of smell is produced by a rose; and that quality in the rose by which it is fitted to produce this sensation we call the *smell of the rose.* Here it is evident that the sensation is original. The perception that the rose has that quality which we call its *smell*, is acquired."

To this doctrine no Cartesian could possibly object; for it is the very account which Des Cartes himself would have given of perception by the organ of smell, as it resolves such a perception into an early association between a certain sensation and that external quality from which we know by experience that the sensation proceeds. Indeed this excellent author repeatedly affirms, that every different perception is conjoined with a sensation which is proper to it; and that the one is the sign, and the other the thing signified. He likewise doubts *, whether children, from the time that they begin to use their senses, make a distinction between things which are only conceived or imagined, and things which really exist. But if the conviction of the present existence of external objects were in perception *instinctive*, we cannot see how there could be room for such a doubt; for the mere senses of children are as perfect as those of full grown men; and they know well the difference between actually sucking their nurses and only thinking of that operation, though they be not capable of expressing that difference in language.

* *Essays on the Intellectual Powers of Man.*

34 Both theories afford intuitive evidence that something exists besides the perception and the sensation.

But if in perception our conviction of the present existence of external objects be not instinctive, what, it may be asked, is the evidence that such objects really exist? This question we shall partly answer in the following section, and more completely when we come to examine Berkeley's theory of the non-existence of matter: but from what has been said already, it is sufficiently evident, that every sensation compels us to believe in the present existence of something different from ourselves, as well as from our sensations.

Sect. III. *Of the Objects of each Sense respectively.*

35 Touch, the sense by which we perceive heat and cold, &c.

Hitherto we have considered sensation and perception in general, and shown that it is not by instinct that we perceive the existence of external objects. This will appear more clearly, if we can ascertain the precise nature of that information which each sense affords us: and in order to this, we shall begin with the sense of *touch*, not only because it is that which is certainly first exercised, but also because there is a meaning in which all the others may be resolved into it.

By means of touch we perceive many things, of which the chief are, heat and cold, hardness and softness, roughness and smoothness, extension, figure, solidity, and motion. Of these perceptions, some are immediate; and others, as we are persuaded, early associations, which may be resolved into a process of reasoning. The perceptions of heat and cold are immediate. When a person for the first time in his life approaches the fire, he feels heat; and when he is first exposed to the frost, he feels cold. What are heat and cold, and where do they reside? They are obviously the reverse of each other; but are they external objects, or mere sensations in the mind? They are undoubtedly sensations which have no existence but when they are felt. To every man not altogether a stranger to these speculations, this proposition is self-evident; but to the bulk of the people it appears an extravagant paradox. To make it plain, however, to the meanest capacity, it is sufficient to observe, that at a certain distance the fire has no perceptible influence upon any person; if that distance be lessened, we feel an agreeable warmth; approach a little nearer, and the warmth becomes disagreeable; and still nearer, it will rise to pain. No man supposes the pain inflicted by a sword to exist in the sword, or anywhere else but in a sentient being. It is equally absurd to suppose pain to exist in fire, or anywhere else but in a sentient being. But that which at one distance is pain, at another is only agreeable warmth; and since warmth and pain are only different degrees of the same feeling, it is equally absurd to suppose the one as the other in the fire. What then is the object of sense when we feel heat? There is obviously no object beyond the present sensation.

36 The nat[ure] of heat [and] cold, wh[ich] are perceived i[m]mediate[ly].

37 Their e[x]ternal c[au]ses.

But has the sensation of heat no cause independent of us? Undoubtedly it has, and experience teaches us that the cause is in the fire. We know that we cannot produce the sensation of heat in ourselves by any mental energy of our own; and we are intuitively certain, that nothing can begin to exist without some cause. A man on the top of a mountain covered with snow, may imagine or remember what he felt when in the neighbourhood of fire, and thus have in his mind what is called an *idea* of heat; but that idea will not warm him (E) like the actual sensation, which no exertion of his own can in such circumstances produce. When he leaves the mountain, however, and approaches the fire, he feels the sensation actually produced, and produced as often as he makes the experiment. He is, therefore, under the necessity of inferring, that in the fire there is some power or quality which, acting either mediately or immediately upon his sense of touch, excites the feeling which is called *heat*. What that power is, we shall perhaps never be able to discover; but it is self-evident, that it is neither heat nor the resemblance of

(E) ——Who can hold a fire in his hand,
By thinking on the frosty Caucasus?
Or cloy the hungry edge of appetite,
By bare imagination of a feast?
Or wallow naked in December's snow,
By thinking on fantastic summer's heat?
Oh no! the apprehension of the good
Gives but the greater feeling to the worse.
K. Richard II.

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of heat, though in vulgar language it is known by that name.

The same reasoning holds good with respect to cold. There is at certain times, and in certain countries, some power in the air which congeals water and causes cold; but that power is as different from the sensation of cold, as the power of fire is different from the sensation of heat, or the point of a sword from a flesh wound.

3 The perceptions of extension, figure, &c. not immediate.

By the sense of touch we perceive extension, figure, solidity, &c. but we do not perceive them *immediately* as we perceive heat and cold; for extension, figure, and solidity, are not sensations. Those perceptions then must be acquired; and more clearly to ascertain the manner in which we acquire them, let us suppose a man from his birth destitute of the sense of sight and the power of local motion, but possessed of intellect and every other faculty which we enjoy.—Such a person, it is obvious, would be capable of every sensation and perception which is *original* to us, except the perception of colours; but we doubt whether it would be possible to give him perceptions of extension, figure, and solidity. Let us try; and as he cannot move a single limb or member of himself, let us suppose a solid substance of small dimensions to be gently pressed against any part of his body; what would such pressure communicate to him? We think it could communicate nothing but a new sensation, to which, as it is neither pleasing nor painful, no name has hitherto been given, except the general one of *feeling*. This sensation he would not know whether to refer to an external or internal cause; or rather he could have no notion whatever of an external cause, though he would at the same time be conscious that the new sensation was not excited by any energy of his own will. Were the pressure to be gradually increased till it rose to pain, our blind man would still be conscious of nothing but a sensation, which could not lead him to the notion of extension, figure, or solidity, because mere sensations cannot be conceived as either solid or extended. Let us next suppose the pressure to be applied successively to different parts of his body; he would now indeed be conscious of successive sensations, but he could not assign to them either extension or *place*: for it has been already shown that the external parts of the body are not themselves sentient; and it shall be shown afterwards, that to a man who has never perceived motion, place is absolutely inconceivable. Lastly, Let us suppose the dimensions of the pressing substance to be greatly enlarged: what would then follow? nothing, we apprehend, but an increase of pain: for though his whole body were pressed *ab extra*, the pressure could affect the individual being which is sentient, not more extensively, but only more violently. It appears, therefore, that a man blind from his birth, and destitute of the power of local motion, could never be made to perceive extension, figure, or solidity.

9 How they are acquired.

Let us now suppose this man to receive by a miracle the use of his limbs, and to be suddenly prompted, by some instinctive impulse, to arise and walk. So long as he met with no obstacle in his way, he would not, we apprehend, acquire by this exercise any correct notions of extension or figure; but were a stone or log of wood of considerable dimensions to be laid across his usual walk, the case would soon be altered. He would feel himself interrupted in his course, and he would at the same instant recognize his wonted sensations of touch. After being twice or thrice thus interrupted, he would learn from experience that the interruption or resistance proceeded from the same cause which in this instance communicated to him the sensation of feeling; and were he to run his hand along the surface of the log or stone, he would perceive the resistance and the sensation continued. As every effect must have an adequate cause, this continued resistance would compel him to believe the continuity of something external in every direction in which he felt his hand resisted; but such continuity of being is all that is meant by the word extension. At the very same time, and by the very same means, he would gradually acquire the perception of figure; for by running his hand in every direction over the surface of the obstacle which opposed him, he would soon perceive it on all sides limited; but the limits of extension is a phrase of precisely the same import with figure. It appears, therefore, that without the power of local motion, men could never, by the sense of touch, acquire the notions of extension and figure; and the same will be found to be the case with respect to hardness and softness.

When we press our hand gently against a stock or a stone, we feel a sensation which is neither painful nor pleasing. When we press it more violently, the sensation becomes painful, and we experience in the object a resistance which we have not power to overcome. When we press butter or pomatum very gently, we have a sensation in all respects similar to that which we felt when we gently touched the stock or the stone. But when we press the butter with violence, we feel no pain, and experience little resistance; for the parts of which it is composed give way before the hand, though the parts of the stock or the stone remained fixed and immoveable. That the parts of one body should thus resist a pressure to which the parts of another so readily yield, must proceed from some difference in the texture of the two bodies: for by the sense of touch we perceive the effects to be different; and are therefore certain that they must proceed either from different causes, or from the same cause operating with different degrees of force. That particular texture which makes the parts of a stone resist the pressure of touch, we call hardness; and the texture which makes the parts of butter or pomatum give way to touch, we call softness. But what hardness and softness are in themselves, touch cannot inform us; for they are neither sensations, nor similar to sensations. We acquire, however, by experience, so complete notions of hardness and softness, that every one who understands the English language perfectly knows the meaning of these words as soon as he hears them; and when he is told that one body is hard and another soft, he knows with absolute certainty that the meaning of the assertion is, that the parts of the body which is said to be hard are held together by some unknown cause operating forcibly, and that the parts of the other are held together by the same or a similar cause operating with less force. 40 Hardness and softness, how perceived.

We acquire the notions of roughness and smoothness in the very same way and by the very same means that 41 Roughness and smoothness.

we

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we acquire ideas of extension and figure. To describe the process at large would certainly be superfluous; for if what we have said concerning our perceptions of extension and figure be just and intelligible, every one will, without farther assistance, discover for himself how he perceives roughness and smoothness. *Motion* shall be considered among the adjuncts of body; but in order to understand what body itself is, it will be necessary, before we dismiss the sense of touch, to inquire how we come by the notion of solidity.

42
Solidity, what; and how perceived.

Solidity is one of those notions, or, in the language of Locke, one of those ideas, which are commonly said to be acquired by the sense of touch. That touch gives the first hint towards our notion of solidity, is certainly true; but that hint must be afterwards improved by the intellect, or we never could have an adequate knowledge of what is meant when any thing is said to be absolutely solid. We know by experience, that we can at pleasure open and shut our empty hand without meeting with any resistance. We know likewise, that when we grasp an ivory ball of three or four inches diameter, no force which we can exert will bring together the several parts of the hand, which were easily brought together when we grasped nothing. In this way do we acquire our first notion of solidity; for the word denotes nothing more in this instance than the power or property of the ball, by which our fingers are excluded from the place which it occupies. Solidity differs from hardness in this respect, that hardness results from the strong cohesion of the parts of a hard body, which renders it difficult to change the places of those parts, as they respect one another; whereas solidity respects the whole mass, and is as essential a quality of water as of adamant. A drop of water, indeed, placed between two plane surfaces of marble, will not like adamant preclude their contact; because the parts of a drop of water, cohering but loosely to one another, give way to the pressure, and escape in every lateral direction. But if a drop of water be confined on all sides, as in a globe of gold, we know from experience that no force will bring the sides of the globe together without forcing the water through the pores of the metal; and hence we infer solidity to be essential to every corporeal substance.

Thus then it appears that of the objects perceived by touch not one is *immediately* perceived except heat, cold, and other sensations. The sensations, as they are not excited by any internal energy of our own, lead us indeed to something external as their cause; and by comparing the different sensations with each other, and observing what effects their external causes have upon our own motions, we are naturally led to conceive these causes as extended, figured, solid, hard or soft, rough or smooth, &c.; but it is obvious that this conception is the result of experience, and a process of mental reasoning.

43
Nothing but mere sensations the object of smell,

On the senses of taste, smell, and hearing, it is needless to say much. The immediate objects of these are confessedly sensations which have no existence but when they are perceived; though experience teaches us to refer them all to external objects as their respective causes. With respect to smell, this has been made sufficiently evident in the preceding section, and it is not less evident with respect to taste and hearing,

44
Taste, and

Certain bodies applied to the tongue and palate, and moistened with the saliva, excite certain sensations which we call tastes. These sensations, however, are not in the bodies; nor can they have any existence but in a sentient being. They are produced in consequence of impulses on the nerves of the tongue and palate, exciting certain agitations in the brain; but the sensation itself is neither impulse nor agitation. Some substances excite tastes which are agreeable, and others such as are disagreeable; and there are not a few which excite no taste at all. Bodies, which applied to the tongue and palate of one man produce tastes that are agreeable, applied to the same organs of another man give him tastes which are disagreeable; and we have all experienced, that the same substance, which, when the organs are sound, excites a sweet or pleasant taste, has, when the organs were disordered, excited a taste which was bitter or unpleasant. These facts, which cannot be controverted, afford the fullest evidence, if evidence were wanted, that taste, as we feel it, is no quality of bodies, nor has any existence out of the mind.

45
Hearing.

The organ of hearing is the *ear*, and its object is sound. It is well known, that sound is produced by certain vibrations of the air striking the tympanum of the ear, and that these vibrations are caused by the sonorous body. Sound, however, is not vibration, nor the idea of sound the idea of vibration. Sound considered by itself is a mere sensation, which can have no existence but in a sentient being. We know by experience, that it is caused by something external; but we know likewise that the effect has no resemblance to the cause. Previous to experience we could not refer sound to any external cause; far less could we discern whether it proceeded from an object above us or below us, on our right hand or on our left. It appears to us self-evident, that if a man born deaf were suddenly made to hear, he would consider his first sensation of sound as originating wholly within himself. Between that sensation and the sensations of touch, taste, smell, and sight, there is no resemblance; nor are there any relations among them, which, previous to experience, could induce him to trace them all to external objects as their several causes. Our deaf man might have learned to refer all his other sensations to their true causes, in some such way as we have described under the sense of touch; but sound would be something so new to him, and so totally different from touch, taste, and smell, that he could attribute it to nothing external.

46
It is by experience that we distinguish different sonorous bodies by their respective sounds.

Experience, however, would soon teach him that the ear is its organ, and the sonorous body its cause; and he would in time learn to distinguish one sound, that of a trumpet for instance, from another, suppose the sound of a bell; and to attribute each to its proper cause, even when neither the trumpet nor the bell was perceived by his other senses. With respect to sounds which we have been accustomed to hear, this is done so instantaneously, that some philosophers have imagined it to be the effect of an instinctive principle in our nature, totally different from experience, and independent of reason. But the fact is not so. Long before we are capable of making sensation and perception objects of reflection, we have heard the sound produced by the ringing of a bell, and seen the object which produced the sound so often, that, when we hear a similar sound

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sound again, we instantly refer it to a *bell*, though we see not the bell from which it proceeds: but this is the effect of habit, and not of instinct. Had we never perceived a bell while ringing by either of our senses of sight or touch, we could not by the sense of hearing acquire any notion of the figure or texture of the body from which the cause of the sound proceeds, though we had heard that sound every day of our lives. It is, indeed, by experience only that we learn to distinguish by the ear whether a sonorous body be before or behind us, on our right hand or on our left; for we find it always difficult to say from what precise quarter a strange sound proceeds; and this difficulty would be heightened to impossibility, had not all sounds something in common. Dr Sparrman relates, that when he first heard the roaring of a lion, he did not know on what side of him to apprehend danger, as the sound seemed to proceed from the ground and to enclose a circle of which he and his companions stood in the centre. The same thing has happened to every man, when the sound was such as he had never heard before; even though it was neither so loud nor so terrific as the roaring of a lion in a desert wilderness: but with respect to sounds which we are daily hearing on each side of us, we soon learn to distinguish with tolerable accuracy whether they be before or behind us, above or below, on our right hand or on our left. All this, however, is the effect, not of instinct, but of experience improved into habit.

47 ...t ori- ...ly per- ...s no- ...t but ...rs, ...h are ...sensa- ...

Sight is justly considered as the noblest and most comprehensive of all our senses. The reason is obvious: for when a full grown man opens his eyes, he perceives houses, trees, rivers, the earth, sun, and moon, &c. and to each of these objects belong figure, extension, colour, &c. which are all perceived instantly by means of this sense. Yet it is certain, that the sense of sight does not originally communicate to us so many perceptions; and there is abundant evidence, that an infant cannot at first, or for some weeks after its birth, distinguish by vision one object from another. *Colour* is the proper object of sight, and for some time its only object; but colour as perceived by us is a mere sensation, which can have no existence but in a sentient being. If this proposition stood in need of proof, we might observe that there are men, and even whole families, who possess the sense of sight in a degree of perfection sufficient for all the purposes of life, and yet cannot distinguish certain colours from each other; blue, for instance, from green, or perhaps from red: and there is no man who can distinguish between some particular shades of blue and green by the feeble light of a candle. Were colours the real qualities of body, this mistake of one for another could never be experienced. No man who possesses the sense of touch ever confounded hardness with softness, a sphere with a cube, or an ell with an inch. The reason is, that hardness and softness, figure and extension, are the qualities of things external; whereas colour being a mere sensation, is nothing but an affection or modification of the sentient being. But it is obvious, that sentient beings, according as they differ from one another, may be differently affected by the same external cause; so that one man may perceive that to be green which all other men perceive to be blue. The immediate external cause of the sensation of colour, is the rays of light reflected from the body, which in common language is said to be coloured. These rays falling upon the pupil of the eye, are refracted differently, according as their incidence is more or less oblique, into points on the retina, where they form a picture of the external object; and from the picture, by means of the optic nerve, is communicated to the brain some impulse or agitation, which produces vision or the perception of colour. As rays of light are corporeal substances, it is obvious that they can act upon body only by impulse; but between impulse and the various sensations of *red*, *green*, *blue*, &c. there is no resemblance. For the laws of reflection and refraction, and for the structure of the eye, see OPTICS and ANATOMY. That which we have to inquire into at present is, how we learn, by means of the sense of sight, to perceive the figure, magnitude, motion, and distance of external objects, or indeed to distinguish one object from another.

A ray of light proceeding, as all rays do, in a straight line, must, however great its length, affect the eye, retina, and optic nerve, as if it were a single point. From this obvious and undeniable fact, Bishop Berkeley predicted *, that a man born blind, who should be suddenly made to see, would at first perceive nothing without him, would distinguish neither the distance, size, figure, nor situation, of external objects; that he would only see in his eyes themselves, or, to speak more properly, would only experience new modifications in his mind, until joining *touch* to *sight*, he formed thus a communication with the external world, and learned, by the simultaneous exercise of the two senses, that natural language in which the *visible* is the sign of the *tangible*. This truth, which was discovered by the bishop merely by contemplating in his own mind the nature of sensation, and the known laws of optics, after having been laughed at for more than 20 years as one of the many dreams of a visionary genius, was completely confirmed by the case of the famous patient whom Cheselden cured of a cataract; and that too, though the cataract does not produce total blindness: which makes it evident, that the first visual perceptions of the patient after his recovery could not be wholly new and unmixed. It may indeed be confirmed at any time by a simple experiment made upon an infant. For several weeks after birth, a child shuts not its eyes upon the sudden approach of an object to them, nor shows the least symptom of distinguishing one distance from another; and it is easy by a little attention to observe, how it gradually learns to distinguish objects at greater and greater distances. Indeed colour, or the immediate object of sight, being a mere sensation or affection of the mind, can have no natural relation whatever to any thing external.

* *Essay towards a new Theory of Vision.*

48 Perception of distance by sight, how acquired.

It is plain, therefore, that distance is in its own nature imperceptible to the eye, and yet it is often perceived by sight. How is this done? We think, in the following manner. Distance is one mode of extension, which, we have already seen, is perceived by means of touch. Of short distances, our first ideas are doubtless acquired by the stretching out and drawing back of our arms; and those ideas are soon so connected with certain sensations which we have in actual vision, that the latter instantly suggests the former.

 Thus,

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Thus, it is a fact known by experience, that when we look at a near object with both eyes, according as it approaches or recedes from us, we alter the disposition of our eyes, by lessening or widening the interval between the pupils. This disposition or turn of the eye, is attended with a sensation of which every man is conscious at the time of vision; and this sensation seems to us to be that which in this case suggests the idea of greater or less distance to the mind. Not that there is any natural or *necessary* connexion between the sensation of which we are conscious, and greater or less distance: for the sensation is wholly internal, and the distance is external. But because the mind has, by constant *experience*, found the different sensations occasioned by different dispositions of the eyes to correspond to different degrees of distance in the object, there has grown a habitual or customary connexion between those sensations and the notions of greater or less distance. So that the mind no sooner perceives the sensation arising from the different turn it gives the eyes in order to bring the *pupils* nearer or farther asunder, than it is instantly impressed with a certain notion of the distance which was wont to be connected with that sensation. Again, An object placed at a certain distance from the eye, to which the breadth of the pupil bears a sensible proportion, being made to approach nearer, is seen more confusedly; and the nearer it is brought, the confusion is always the greater. The reason of all this is known to every optician: but it being constantly experienced by those who never dipt into optics, there arises in the mind of every man a habitual connexion between the several degrees of confusion and distance, the greater confusion still implying the less distance, and the less confusion the greater distance. It is of no avail to say, that between confused vision and distance, great or small, there is no necessary connection: for there is as little connexion between a blush in the face and the mental feeling of shame; and yet no sooner does a man of observation perceive that particular colour in the face of another, than it suggests to him the notion of that feeling or passion with which he has constantly observed it accompanied.

In these ways, however, we perceive only small distances. Of distances more remote our judgment is formed from other data; and happily these data are not far to seek. It is a fact known to every man who is not totally ignorant of the science of optics, that a greater number of rays fall upon the eye when reflected from a body near at hand, than can fall from the same body at a distance; and as those rays operate by impulse, it is self-evident that the impression must be stronger, and of course the sensation or colour more vivid, when the body is near than when it is distant. Now having acquired the notion of the true distance of objects by motion and the sense of touch, and finding by uniform experience, that as they are near or far off, the sensation or colour which they excite in the mind through the organ of vision is more or less vivid, those degrees of sensation come to be so closely associated with the respective distances of the object, that the one instantly suggests the other.

49 How figure is perceived by sight.

It is just so that we perceive figure by sight. Having experienced by the sense of touch that one surface is a square and another a circle, that one body is a cube and another a sphere; and finding our sense of sight differently affected by the square and the circle, by the cube and the sphere; these different affections come to be so closely connected in our minds with the figures of the respective bodies, that long before we are capable of reasoning on the subject the one is never present to us without suggesting the other. Nay, so complete in this case is the connexion or association, that we cannot even in idea abstract the colour from the figure; though it is certain that colour is a mere sensation, and figure an external quality; that colour alone is immediately perceivable by the eye, and the notion of figure suggested by the colour. We are aware that it has been affirmed, and affirmed with great vehemence, that figures of two dimensions are immediately perceived by the eye, and perceived with greater accuracy than by the sense of touch. But they who insist upon this doctrine affirm likewise, contrary to experience and the clearest reasoning, that the immediate objects of sight are external, and that colour is a quality of bodies. In the arguments too by which they support their hypothesis, they seem to confound sight as an affection of the mind, with the picture on the bottom of the eye, as if the retina were the sentient being; whereas the retina and picture are no more than instruments of sensation. It is indeed a fact, that the picture has the same figure nearly with the plane of the object which is presented to the eye; as when the object is a sphere, the picture is a circle variously shaded in colour. It is likewise a fact, that the picture is enlarged in proportion as the object is brought near, and diminished as it is carried to a distance. But these facts are known only to persons skilled in optics; and therefore it is evident, that though calculations may be raised from them by mathematicians to determine the distance and figure of external objects, they cannot possibly be the data from which distance and figure are inferred by the vulgar, who know not that such pictures on the retina exist. Besides all this, it is universally known, that a painter, by laying on his colours properly, can make a plain square surface appear to the eye in certain positions as an oblong or as a cube, and a plain circular surface as a concave or a convex hemisphere. But not one of these things could possibly be done, were figure, or indeed any thing else than colour, the immediate object of vision.

50 Magnit[ude]

As we see distance and figure, so we see magnitude; and we see both in the same way that we see shame or anger in the looks of a man. The impression made upon the bottom of the eye by rays reflected from a large magnitude, must necessarily be different from the impression made by rays reflected from a magnitude that is less. This is self-evident; and since the impression *ab extra* is in some way or other the cause of that sensation, which is all of which we are originally conscious in vision, it is obvious that the sensation, like every other effect, must correspond to the cause from which it proceeds. Being therefore conscious of different sensations; and having, at an earlier period than we distinctly remember, learned by experience to refer them to different magnitudes; no sooner is each sensation excited than it suggests the notion, or, if you please, the perception, of that magnitude with which it is connected. So completely is this association fixed in the mind, that when we look at a known object, its real ects of respec- Senses.

real magnitude appears to be as instantly observed as its colour, whilst we hardly attend at all to the particularity of the sensation by which the magnitude is suggested. It is, indeed, customary with writers on optics to distinguish between tangible and visible magnitude, as if any kind of magnitude were the immediate object of vision: but this is not so: for magnitude is something external, whereas the immediate object of vision is a mere sensation. What has introduced into science this mode of speaking is the following fact, that as we approach a distant object it appears to the eye larger and larger every step, and less and less as we recede from it; whereas the tangible magnitude of an object is always the same. The reason of this apparent change of magnitude to the eye, according to the distance at which any particular object is viewed, is, that from a near object rays of light fall in greater numbers and more diverging than from the same object viewed at a distance. This of course alters the nature of the visible sensation: each common sensation is in the mind closely linked with a particular notion of magnitude; and by the exercise of sight and touch we have learned from experience, that the particular sensation caused by diverging rays must be referred to a larger magnitude than that which is caused by parallel rays proceeding from the same distance.

51 ble sensations a l of natural language.

Upon the whole, then, we think ourselves entitled to conclude, that the proper and original objects of vision constitute an universal language of the Author of Nature, by which we are instructed how to regulate our actions, in order to attain those things that are necessary to the preservation and well-being of our bodies, as also to avoid whatever may be hurtful or destructive to them. It is principally by the information of this language that we are guided in all the transactions and concerns of life: And the manner in which it signifies and marks to us the objects which are at a distance, is similar to that of languages and signs of human appointment, which do not suggest the things signified by any likeness or identity of nature, but only by a habitual connection, which experience has made us to observe, between them. This language of the eye, like the language of the tongue, suggests by one sensation what may be resolved into a variety of perceptions. A tree is composed of a trunk, branches, leaves; it has colour, figure, size; and all these things are at once suggested to the mind by the two words *spreading oak*. Just so it is with respect to vision: the sensation received by the eye suggests at once the *trunk*, *branches*, *leaves*, *colour*, *figure*, and *size* of the oak, and suggests them all as the qualities of one object.

Chap. II. *Of* Retention *and* Ideas.

52 sations l perceptions remain for a y short e after removal of their ects. Hartley Man.

From the experiment with the burning coal mentioned in N° 31. it is apparent, the sensations excited through the eye, together with their corresponding perceptions, remain in the mind for a short time after the external exciting cause is removed. The same thing appears from another experiment which was first made by Sir Isaac Newton, and which every man may repeat for his own satisfaction. It is universally known*, that a proper mixture of the seven original colours, *red*, *yellow*, *green*, *blue*, &c. constitutes that uniform appearance which we call *white*. But when these colours are made to pass in a rapid consecution before the eye, they excite the very same perception as when they are properly mixed, which is a satisfactory proof that the impression made by each separate colour remains in the brain until a revolution of all the colours be completed; for nothing but the impression of all the colours at *once* can produce the sensation and perception of *white*. Indeed no person capable of paying the proper attention to these things, can keep his eye fixed upon a luminous object, and afterwards shut it, without experiencing that the sensation and perception remain for some time after the external object is shut out, and that they go off gradually till they leave behind them the mental appearance, which is properly called an *idea* of the object.

Retention and Ideas.

The same continuance of the sensation after the removal of its cause is equally observable in the sense of hearing; for every sound which we hear is reflected by the neighbouring bodies; and therefore consists in reality of a variety of sounds succeeding each other at different distances of time, according to the distances of the several reflecting bodies. Yet this causes no confusion or apparent complexity of sound, unless when the distance of the reflecting bodies is very considerable, as in spacious buildings.

With respect to the continuance of the sensation of touch, doubts have been started: but for these there is as little room as for doubting the continuance of the sensations of seeing and hearing. The continuance of heat after the heating body is removed, and of the smart of a wound after the instant of infliction, are proofs that every sensation of touch does not vanish with its cause. A man unused to the motion of a ship or coach, after having been a day at sea or on the road, feels or imagines he feels the rolling of the ship or the jolting of the coach after he is in bed and actually at rest. Of these facts we know not what other account can be given, than that the agitation in the brain, which is the immediate cause of the sensation of touch, remains for some time after the external cause of the agitation is removed.

As to the senses of taste and smell, Dr Hartley seems to think that there is no clear and direct evidence for the continuance of their sensations after their proper objects are removed: but in this instance the ingenious author does not do justice to his own theory. Let any man eat onions, garlic, or any other thing of a very pungent taste, and immediately wash his mouth with fresh water, so that he may be sure no part of the sapid body remains on his tongue or palate. According to this doctrine, the taste of the onion or garlic should instantly vanish with its object; but the fact is otherwise. Whoever shall make the experiment, will find the sensation to remain a considerable time: not indeed in its original force, but weakened no more than what it must necessarily be by the introduction of a new sensation excited by the water. It is more difficult to ascertain the permanency of smell: but analogy inclines us to believe, that in this particular it resembles the other senses, though we know not how to direct the reader to an experiment which will give him absolute conviction.

Whether the cause of these continued sensations, after the removal of their objects, be in the brain alone, in

Retention and Ideas.

in the mind alone considered as an immaterial being, or in both together, is of very little importance; because, taking the mind and its internal organs as one *metaphysical whole**, it matters not to our present inquiry, where this retentive power resides, as long as it can be proved to exist within us: for it seems evident, that what has the faculty of retaining a sensation when no longer acted upon by the object which excited it, must also have a power to preserve the vestiges of that sensation even after the sensation itself shall be entirely obliterated. This is in fact the case with the mind. When an object which we have once perceived is most remote from our thoughts, we are certain that there is within us a capacity, disposition, tendency, or power, by which a representation of that object may be at any time revived and presented to the intellect. Thus the same inherent power of the mind and its internal organs, which retains a sensation and perception in the absence of the object by which they were excited, can also reproduce that perception, or bring into the view of the intellect something exactly similar to it. The reproduction will not indeed be so lively as the original perception when accompanied with its corresponding sensation, because sensation and actual perception are affected by a double cause, the action of the external object upon the organ, nerves, and brain, and the corresponding energy of the mind or sentient principle; whereas, in the reproduction, the mind seems to act solely by its own power, and certainly without the assistance of external objects. This reproductive power is commonly called *memory*. By many of the ancient philosophers, and by *M. Schwab*, with one or two others among the moderns, it is called *imagination*. We do not choose either to revive antiquated modes of expression, or to introduce innovations of our own; but as we cannot disapprove of the ancient phraseology, after the definitions which the reader will by and by find of *imagination*, *memory*, and *recollection*, as given by Mr Harris, we have prefixed to this chapter the general title of *retention*, which comprehends them all.

53 Hence we have that power or faculty called *memory*.

* See *An Essay on the Reduction of the Faculties of the Mind, by M. Schwab.*

54 The opinions of philosophers respecting memory.

When one recals an object of sight by the power of memory, it appears to him precisely the same as in the original survey, only less distinct, and with a conviction (which is perhaps the result of experience) that the real object is not immediately before him. How is an object recalled by the power of memory? Does the man endeavour to form in his mind a picture or representative image of the object? Let us listen to the answers given by different philosophers to this question.

55 The Peripatetics and Platonists

The sentiments of the Peripatetics, as expressed by *Alexander Aphrodisiensis*, one of the earliest commentators on *Aristotle*, are thus translated by Mr Harris in his Hermes.—" Now, what fancy or imagination is, we may explain as follows: We may conceive to be formed within us, from the operation of the senses about sensible objects, some impression (as it were), or picture in our original sensorium, being a relict of that motion caused within us by the external object; a relict which, when the external object is no longer present, remains, and is still preserved, being as it were its image; and which, by being thus preserved, becomes the cause of our having memory. Now such a sort of relict, (and as it were) impression, they call *fancy* or *imagination* (E)." A passage from ALCINOUS *of the doctrines of Plato*, as rendered into English by Dr Reid†, shows that, in this theory, as in that of perception, the Platonists agreed with the Peripatetics. " When the form or type of things is imprinted on the mind by the organs of the senses, and so imprinted as not to be deleted by time, but preserved firm and lasting, its preservation is called *memory*."

Retenti and Ide

† Essays the Intel lectual Powers Man.

Mr Harris, who was deeply read in the ancient philosophy, and who considered the authority of Aristotle and Plato as superseding all reasoning and all inquiry, after justly observing, that if the soul had no other faculties than the senses, it could never acquire the least idea of *time*, thus expresses himself on the subject before us: " But, happily for us, we are not deserted here. We have, in the first place, a faculty called *imagination* or *fancy*; which, however as to its *energies* it may be subsequent to sense, yet is truly prior to it both in *dignity* and *use*. This it is which *retains the fleeting forms of things*, when things themselves are gone, and *all sensation* is at an end. That this faculty, however connected with sense, is still perfectly different, may be seen from hence. We have an *imagination* of things that are gone and extinct; but no such things can be made objects of *sensation*. We have an easy command over the objects of our *imagination*, and can call them forth in almost what manner we please; but our *sensations* are necessary when their objects are present, nor can we controul them but by removing either the objects or ourselves. As wax would not be adequate to its business of signature, had it not a power to retain, as well as receive; the same holds of the SOUL, with respect to *sense* and *imagination*. SENSE is its *receptive* power: IMAGINATION its *retentive*. Had it sense without imagination, it would not be as wax but as water; where, though all impressions may be instantly made, yet as soon as made they are entirely lost. Thus then, from a view of the two powers taken together, we may call SENSE (if we please), *a kind of transient imagination*; and IMAGINATION, on the contrary, *a kind of permanent sense*."

Great part of the office which is here given to imagination, is in common English attributed to memory; but between these two faculties, as well as between them and recollection, the author accurately distinguishes thus:—" When we view some *relict* of sensation reposed within us, *without thinking of its rise*, or *referring it to any sensible object*, this is FANCY or IMAGINATION. When we view some such *relict*, and *refer it withal to that sensible object which in time past was* its

56 disting properl betwee imagin tion an memor &c.

(E) The original is as follows: Τι τοινυν εστιν ἡ φαντασια ωδε αν γνωρισαιμεν δει νοειν εν ημιν απο των ενεργειων των περι τα αισθητα, οιον τυπον τινα αναζωγραφημα εν τω πρωτω αισθητηριω, εγκαταλειμμα τι της υπο του αισθητου γινομενης κινησεως, ὁ και μηκετι του αισθητου παροντος, υπομενει τε και σωζεται, ον ὡσπερ εικων τις αυτου, ον και της μνημης ημιν σωζομενον αιτιον γινεται το τοιουτον εγκαταλειμμα, και τον τοιουτον ὡσπερ τυπον, φαντασιαν καλουσιν. *Alex. Aphrod. de Anima*, p. 135. *Edit. Ald.*

its cause and original, this is MEMORY. Lastly, the *road which leads to memory through a series of ideas however connected, whether rationally or casually*, this is recollection."

57 Objections to their theory. Of this theory we shall only remark, that if we could understand the words *picture* and *form* in a metaphorical sense, as candour obliges us to understand Locke's *images* in the mind, the doctrine of *Alexander Aphrodisiensis* would be very little wide of the truth. Experience teaches us that memory as well as perception depends upon the state of the brain; and as it is undeniable, that when a man to-day contemplates an object which he perceived yesterday, or at any former period, he has a view of it in all respects similar to the original perception, only fainter and less distinct, it is extremely probable, that an impression *ab extra*, which produces a sensation and perception, leaves behind it some *tendency* in the brain, to vibrate as in the actual sensation, and that this *tendency* is carried into *effect* by the internal energy of the mind itself. But in the Peripatetic philosophy, *pictures* and *forms* in the *sensorium* were considered as real things, and by no means as metaphorical expressions. This is evident from their being constantly compared to the impression of a seal upon wax, and from their converting the *materia prima* from something, which can neither be seen nor felt, into visible and tangible body, of which we shall treat afterwards. Now it being certain that on a being immaterial, no corporeal *form* can be impressed, and repeated dissections having shown that no such forms are in fact impressed on the brain, this whole theory is at once overturned.

58 Locke's doctrine concerning memory. Modern philosophers having denied that there are real *images* or *forms* in the mind during the immediate act of perception, cannot consistently with themselves admit such images in the act of retention, or when those things which were formerly objects of perception are recalled to the mind by the power of memory. Mr Locke's doctrine is, "that the mind retains these simple ideas which it first received from sensation or reflection, two ways: first, by keeping the idea, which is brought into it, for some time actually in view, which is called CONTEMPLATION: and secondly, by the power which we have to revive again in our minds those ideas, which, after imprinting, have disappeared, or have been, as it were, laid out of sight; as when we conceive heat or light, yellow or sweet, the object being removed. This (he says) is MEMORY; which is, as it were, the storehouse of our ideas *.

Essay, b. ii. c. 10.

To explain this more fully, he immediately adds the following observation:—" But our ideas being nothing but actual perceptions in the mind, which cease to be any thing where there is no perception of them, this laying up of our ideas in the repository of the memory, signifies no more than this, that the mind has a power in many cases, to revive perceptions which it has once had, with this additional perception annexed to them, that it has had them before. And in this sense it is, that our ideas are said to be in our memories, when indeed they are actually nowhere; but only there is an ability, in the mind, when it will, to revive them again, and, as it were, paint them anew on itself, though some with more some with less difficulty, some more lively and others more obscurely. And thus it is, by the assistance of this faculty, that we are said to have all those ideas in our understandings, which, though we do not actually contemplate them, yet we can bring in sight, and make appear again, and be the objects of our thoughts, without the help of those sensible qualities which first imprinted them there."

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To attempt a defence of the accuracy of this language would be vain; but as the author's meaning is sufficiently obvious, his expressions may be easily and certainly corrected. Had Locke said—" But our ideas being nothing but scenes or appearances in the mind, which cease to be any thing when there is no perception of them, thus laying up of our ideas in the repository of the memory signifies no more but this, that the mind has a power, in many cases, to revive scenes which it has once viewed, with this additional perception annexed to them, that it has viewed them before;" there would have been no room for the many petulant remarks which have been made upon the passage.

But against this account of memory, a much heavier charge has been brought than that which regards the propriety of the language. It has been said, that the additional perception, which according to Locke, attends the revival of our ideas by the power of memory, " would be a fallacious perception, if it led us to believe that we had them before, since they cannot have two beginnings of existence: nor can we believe them to have two beginnings of existence; we can only believe that we had formerly ideas or perceptions very like to them, though not identically the same." Let us examine this question somewhat narrowly: for if it be really true, that in the sense in which the word *same* is here used, we cannot twice contemplate the same idea, all confidence in memory would seem to be at an end. 59 objected to.

Suppose a man to stand on some of the rising grounds about Edinburgh, the Caltonhill for instance, and from that eminence to view the glorious prospect of the coast of Fife, the ocean, the frith of Forth, and the little islands scattered in the frith. Let him go away, and return next day to the same place and look the same way: we would ask whether he has the same *view* or *perception* which he had the day before? The man must surely be very captious who would say that he has not: and yet it is certain that the energy of mind by which he perceives on one day cannot be identically the same with that by which he perceived on another; nor are the rays of light which fall upon his eyes on the second day, identically the same with those which fell upon his eyes and occasioned vision on the first day. Let the same man now shut his eyes, and contemplate the various objects at which he had been just looking. They will appear to him in all respects the same as when viewed by means of his organs of sight, only fainter and less distinct, with this additional conviction, that the immediate objects of his present contemplation are not real external things, but *ideas* or *mental representations* of those things which had so lately been the objects of his sight. Let him think no more about the matter for some days, and then exert his powers of memory. We have no hesitation to say, that in the sense of the word *same*, as used by Mr Locke, the very same ideas will recur 60 The objection obviated.

recur and be present to his intellect which were present to it at the former contemplation. The second energy of memory or imagination, or whatever it may be called, is not indeed identically the same with the first; nor is that agitation or motion, or whatever other affection of the brain is necessary to memory, identically the same at the second time as at the first: but the mind exerting itself in the very same manner at the one time as at the other, produces the same kind of agitation in the brain, and is itself affected in the very same way at the second as at the first exertion. Whence it follows, that the second *ideal scene* will be as much the same with the first, as the second *actual perception* is the same with the first, and the two ideal scenes, and the two actual perceptions, are respectively said to be the same with each other, only because they impress the mind with a conviction that they were occasioned by the same external objects.

But though we think Locke's doctrine, with respect to memory, may be thus easily vindicated from the charge of fallaciousness, we must acknowledge that to us it appears not to be of much value. It teaches nothing, but that the mind has a power to retain ideas of those objects which it formerly perceived, and in many instances to recal them as occasion may require. But these are truths known to all mankind, to the clown as well as to the philosopher.

61 The opinion of Hume.

Philosophers in general have paid less regard to the retentive faculties of the mind than to its original powers of perception. Perhaps they imagined, that as memory depends upon perception, and in some respects appears to resemble it, a competent knowledge of the nature of the former faculty would lead to that of the second. Be this as it may, Mr Hume, who was at some pains to detail his notions of perception, has in his Philosophical Essays only dropt concerning memory and imagination a few hints, so loosely thrown together, that, if he had not elsewhere expressed himself with more precision, it would have been difficult to discover his real meaning. According to him, that which is commonly called the *perception of an external object*, is nothing but a strong impression upon the mind; and that which is called the *remembrance of a past object*, is nothing but a present impression or idea weaker than the former. Imagination is an idea weaker than the idea or impression which he calls *memory*. This seems to be a wonderful abuse of language. Impressions are not perceptions; and, if possible, they can still less be called *ideas*, which are but secondary perceptions. It is likewise far from being true, that an idea of imagination has necessarily less vivacity than an idea of memory. We have seen Mr Hume, and have at the present moment an idea of his form and dress: we can likewise imagine to ourselves a centaur; and though a centaur was never seen, and therefore cannot be *an impression repeated by memory*, our idea of the monster is much more lively and distinct than that of the philosopher.

62 Of Dr Reid.

Dr Reid having observed of memory *, that it is by it we have an immediate knowledge of things past; that it must have an object; that in this respect it agrees with perception, but differs from sensation, which has no object but the feeling itself; and that every man can distinguish the thing remembered from the remembrance of it—proceeds to inquire what memory is. And, "First (says he), I think it appears that memory is an original faculty given us by the Author of our being, of which we can give no account but that we are so made. The knowledge (continues he) which I have of things past by my memory, seems to me as unaccountable as an immediate knowledge would be of things to come (F); and I can give no reason why I should have the one and not the other, but that such is the will of my Maker. I find in my mind a distinct conception and a firm belief of a series of past events; but how this is produced I know not. I call it *memory*; but this is only giving a name to it; it is not an account of its cause. I believe most firmly what I distinctly remember; but I can give no reason of this belief. It is the inspiration of the Almighty which gives me this understanding. When I believe the truth of a mathematical axiom or of a mathematical proposition, I see that it must be so: every man who has the same conception of it sees the same. There is a necessary and an evident connection between the subject and the predicate of the proposition; and I have all the evidence to support my belief which I can possibly conceive. When I believe that I washed my hands and face this morning, there appears no necessity in the truth of the proposition. It might be or it might not be. A man may distinctly conceive it without believing it at all. How then do I come to believe it? I remember it distinctly. This is all I can say. This remembrance is an act of my mind. Is it impossible that this act should be, if the event had not happened? I confess I do not see any necessary connexion, between the one and the other. If any man can show such a necessary connexion, then I think that belief which we have of what we remember will be fairly accounted for: but if this cannot be done, that belief is unaccountable; and we can say no more than that it is the result of our constitution. Our original faculties are all unaccountable: Of these memory is one. He only who made them comprehends fully how they are made, and how they produce in us not only a conception, but a firm belief and assurance, of things which it concerns us to know."

On this account of memory we shall make no remarks. There is a certain sense of the words, in which every thing which the author has said on the subject is undoubtedly

* Essay on the Intellectual Powers of Man.

(F) If memory depends upon the state of the brain as it has been affected in past perceptions, this appears to us a strange position. Perhaps the excellent author means nothing more, than that it is as unaccountable to us, that impressions on the brain should cause perception, and the vestiges of those impressions should cause remembrance, as how the mind might not perceive things to come without the intervention of impressions on the brain. If this be the meaning, no man will controvert it: for it is impossible to discover the nature of that relation which subsists between an impression and perception; but that there is such a relation, we know from experience.

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undoubtedly just; and it would be very uncandid to take his words in any other sense. But though memory, as it is the result of that constitution which was given us by God, and not the offspring of habit or human contrivance, is unquestionably an original faculty; and though it is therefore impossible to account for it so fully as to silence every inquiry which may be made, yet we could wish that Dr Reid had bestowed a little more pains upon it, in order to discover if possible in what respects it resembles or differs from perception. He has well observed, that there are laws of nature by which the operations of the mind are regulated, as well as laws of nature which govern the material system. As the latter are the ultimate conclusions which the human faculties can reach in the philosophy of bodies, so the former are the ultimate conclusions which we can reach in the philosophy of minds. The more general that these laws are in both cases, the more useful they are and the more satisfactory: for as they are themselves inexplicable, the fewer they are in number, and the more comprehensive each, the fewer will those phenomena be for which we can give no account. Thus, as we know not what makes the planets tend to the centre of the sun, or heavy bodies tend to the centre of the earth, we can give no other account of these phenomena, but that, as they appear to be of the same kind, it is reasonable to conclude that they proceed from similar causes. What the cause is of this tendency of bodies towards each other, we know not. We call it *gravitation*, and employ it to account for all phenomena of the same kind. In like manner it is universally allowed, that as we know not how mind and matter operate upon each other, there is something in perception wholly unaccountable. That perception follows sensation; and that there is no sensation which is not occasioned by some affection of the brain, proceeding from some impression *ab extra*; we have the evidence of experience: but how a particular affection of the brain should excite a sensation in the mind, we know not; though we may here, as in the corporeal system, attribute similar effects to the same or similar causes. Thus, if when we exert an act of memory we have the same appearance of things as in the original act of perception, the rules of philosophizing authorize us to refer both phenomena to the same general law; just as they authorize us to refer the motion of the planets and of projectiles to the same general law. On the other hand, if we perceive no similarity between memory and perception, we have made no progress in the philosophy of mind; for in that case we have discovered two phenomena proceeding from two causes totally different from each other, and both inexplicable. Although we scarcely hope to throw any light upon a subject which Dr Reid has not attempted to illustrate, we shall state a few facts respecting the memory, and submit to the reader the conclusions to which we think these facts lead.

63 The appearance of sensible objects when recalled by the power of memory.

1. Objects once perceived by the senses, when recalled to the mind by the power of memory, appear precisely the same as in the original perception, only less distinct *. For example, having seen yesterday a spreading oak growing on the bank of a river, and having heard a shepherd play, and handled a square stone, we endeavour to recal to our mind these objects which are now absent. How is this operation performed? Do we endeavour to form in our minds pictures of them or representative images? or, does our intellect survey the types or forms which, according to Aristotle, those objects left in the imagination when originally perceived? Neither of these things is done. We conceive ourselves as standing in the same place where we stood yesterday; upon which we have perceptions of the objects similar in all respects to the perceptions which we had when we employed our eyes, our ears, and our hands. The tree appears, as it were, before us; faint indeed, but attended with all the objects which we observed around it yesterday: we seem to hear the sound of the pipe confusedly, and at a distance; to move our hands over the stone, and to feel the same surfaces and the same angles which we felt in the original perception. In this recollection we are not conscious of pictures or images more than in the original survey. The perceptions seem to be of the tree and river themselves, of the sound itself, and of the stone itself, exactly as at the first; and yet we are satisfied that in the act of remembrance we perceive no such object as a *real* tree, pipe, or stone. That these are facts, every man must be convinced who attends to the energies of his own mind when exerting the powers of retention: and therefore it is, in our opinion, with no impropriety that Mr Harris says, we may call SENSE, if we please, *a kind of transient imagination;* and IMAGINATION, on the contrary, *a kind of permanent sense;* for if these two faculties, as far as the mind or intellect is concerned, be not the same, they seem to resemble each other much.

* *Appendix to Elements of Criticism.*

64 What ideas remain longest in the memory.

2. The *primary* perception of a *visible* object is more complete, lively, and distinct, and remains longer in the *sensorium* than that of any other object. We know likewise by experience, that an *idea* or *secondary* perception of a visible object is as much more complete, lively, and distinct, than the idea of any other object, as was the *primary* perception; and that we remember things which we have seen for a longer time than sounds which we have heard, or than tangible objects which we have only handled. Yet there seems to be a constant decay of all our ideas, even of those which are struck (G) deepest and in minds the most retentive; so that if they be not frequently renewed by repeated exercise of the senses, or by reflection on those objects which at first occasioned them, the print (G) wears out,

(G) These expressions, which mention ideas as things which are *deep struck*, and as *prints which wear out*, are the expressions of Locke. We hope it is needless to warn our readers, that they are used by us, as they were by him, in a metaphorical sense. On these subjects it is impossible to write without metaphor; which, while the meaning is obvious, no man will condemn, who reflects that the words of language were not invented by metaphysicians, and are for the most part *literally* significant only of sensible objects.

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out, and at last there remains nothing to be seen. Concerning ideas, it is easy to remark, that those remain longest and clearest in the memory which are derived from two or more senses, especially if the sense of sight be one of the number, or which are oftenest refreshed by a return of the objects which produced them. Hence a man has a longer and more distinct remembrance of what he has seen than of what he has only heard, of what he has both seen and felt than of what he has only seen; and the ideas which we have of heat and cold, of hunger and thirst, and of all those things which most frequently affect our senses, are extremely clear, and are never quite lost whilst the mind retains any ideas at all.

65 Memory a kind of habit.

3. Memory appears to be a kind of habit, which is not always in exercise with regard to things we remember, but is ready to suggest them when there is occasion. The most perfect degree of this habit is, when the thing presents itself to our remembrance spontaneously, and without labour, as often as there is occasion. A second degree is, when the thing is forgotten for a longer or shorter time, even when there is occasion to remember it, and yet at last some incident, such as a violent passion *, which agitates the whole mind and sensorium, tumbles the idea, as it were, out of its dark corner, and brings it into view without any search. A third degree is, when we cast about and search for what we would remember, and after some labour find it out. This searching faculty of the soul is by Aristotle called ἀναμνησις, by Dr Reid and others *reminiscence*, and by Mr Harris *recollection*. Should it be said, that what we *will* to remember we must already conceive, as we can will nothing of which we have not a conception; and that, therefore, a *will* to remember a thing, seems to imply that we remember it already—we answer, with Dr Reid, that when we will to remember a thing, we must indeed remember something relating to it; but we may have no positive idea or conception of the thing itself, but only of the relation which it bears to that other thing which we do remember. Thus, one remembers that a friend charged him with a commission to be executed at such a place, but he has forgotten what the commission was. He applies himself to discover it; and *recollects* that it was given by *such a person*, upon *such an occasion*, in consequence of such a *conversation*: and thus by a train of thought he is led to the very thing which he had forgotten and wished to remember. To this operation it is not always necessary that the relations between the various ideas which the mind turns over be very close, or have their foundation in nature; for a casual connexion is often sufficient. Thus, from seeing a garment, we think of its owner; thence of his habitation; thence of woods; thence of timber; thence of ships; thence of admirals; thence of cannons, iron, furnaces, and forges," &c.

* *Reid's Essays on the Intellectual Powers of Man, Locke's Essay, &c. and Harris's Hermes.*

66 In recollection one idea suggests another, and why

That, in the process of recollection, one idea should suggest another, may be easily accounted for. When, in perception, our minds are exposed to the influence of external objects, all the parts and properties, and even the accidental variable adjuncts of these objects, are perceived by full-grown men at the same time; so that the whole group makes but one impression upon our organs of sense, and consequently upon the mind. By these means all the parts of the simultaneous impression *, and consequently of the perception occasioned by that impression, are so intimately associated or linked together, that the idea of any one of them recurring at any future period, generally introduces the ideas of all the rest. But as the necessary parts and properties of any thing are more closely linked together, and occur more frequently than any particular variable adjuncts, it is obvious, that by the idea of any one of these properties, the idea of the rest, and of the object itself, will be more readily introduced than by the idea of any variable adjunct. It seems, however, to be certain, that we have no power of calling up any idea at pleasure, but only such as have a connexion, either in nature or by means of former associations, with those that are at any time present to the mind. Thus the sight, or the idea, of any particular person, generally enables us to recollect his name, because his name and his person have been constantly associated together. If that fail to introduce the name, we are at a loss and cannot recollect it at all till some other associated circumstance help us. In naming a number of words in a sentence, or lines in a poem, the end of each preceding word or line being connected with the beginning of the word or line which succeeds it, we can easily repeat them in that order; but we are not able to repeat them backwards with any ease, nor at all till after many fruitless efforts. By frequent trials, however, we acquire at last a facility in doing it, as may be found by making the experiment on the names of number from one to twenty. It is indeed, probable, that in the wildest flights of *fancy*, no single idea occurs to us but such as had a connexion with some other idea, perception, or notion, previously existing in the mind, as shall be shown more fully in a subsequent chapter.

* *Hartle on Man.*

67 memory depends the stat the brai

4. "Memory appears to depend entirely or chiefly upon the state of the brain †. For diseases, concussions of the brain, spirituous liquors, and some poisons, impair or destroy it; and it generally returns again with the return of health, from the use of proper medicines and methods. It is observable, too, that in recovering from concussions and other disorders of the brain, it is usual for the person to recover the power of remembering the then present common incidents for minutes, hours, and days, by degrees; also the power of recalling the events of his life preceding his illness. At length he recovers this last power perfectly; and at the same time forgets almost all that past in his illness, even those things which at first he remembered for a day or two. Now the reason of this seems to be, that upon a perfect recovery the brain recovers its natural state, and all its former affections and tendencies; but that such affections or tendencies as took place during the preternatural state, i. e. during the patient's illness, are obliterated by the return of the natural state." All this we are induced to believe; because, though it is a fact incontrovertible, that in certain diseases the memory is impaired, and recovers its vigour with the return of health, it is not conceivable that the mind itself should suffer any change by diseases, concussions, or spirituous liquors, &c.

† *Hartl on Man.*

From these facts we are strongly inclined to conclude, ention Ideas.

68 rnal ets operating on enses some anent t in the b...

clude, that the power of the *mind*, or *immaterial* (H) *principle*, by which it remembers past events, differs not from that by which it perceives present objects. In perception, impressions are made upon the organs of sense, which are communicated to the brain; and, by some unknown means, occasion sensations which are followed by the perception of the external object. When by the power of memory we recal past objects of sense, the mind has the same view of them as in the original perception, except that they appear fainter, less distinct, and generally more distant. We have, therefore, reason to conclude, that in the act of remembrance the brain is affected in the same way, though not so forcibly, as in perception. That memory depends as much as perception upon the state of the brain, is confirmed by daily experience; and therefore there cannot be a doubt but that external objects, operating upon the senses, nerves, and brain, leave some permanent effect behind them. What that effect precisely is we cannot know, and we need not desire to know; but that they leave *some* effect we have as good evidence as that the planets are moved round the sun by forces of the same kind with those by which projectiles are moved on the earth. Could we suppose that they leave real *prints* or *impressions* behind them, which we confess to be very little probable, memory would seem to be nothing but the perceptive power of the mind turned to those impressions. If the permanent effect of impressions by external objects be, as Dr Hartley supposes, only a tendency in the brain to vibrate as in the original perception, remembrance will result from the mind's operating upon the brain as in actual perception; and the reason that ideas of memory are fainter than perceptions of sense, is, that the former are produced by a single, and the latter by a double, operation.

69 y the ory nces to ection, then ually ys.

This theory appears to be greatly confirmed by the following well known facts, that children soon commit to their memory any thing which they understand, and as soon forget it; that the powers of memory gradually advance to perfection, and then gradually decay; and that old men remember more distinctly what they perceived in their youth, than what they perceived a year ago. For if the memory belonged wholly to the pure intellect, and had no dependence upon the brain, it is not easy to conceive how it should advance towards a state of perfection and afterwards decay. A being which is unextended and indivisible, can suffer no change either in its essence or in its faculties: the ideas which it had once retained, it would retain for ever. But if memory be occasioned by some relict of sense left in the brain, it is easy to see how all those changes should take place: and therefore, though we have the weight of Dr Reid's authority against us, we cannot help thinking that Aristotle was in the right, when he imputed the shortness of memory in children to this cause, that their brain is too moist and soft to retain impressions made upon it; and that he was likewise in the right, when he imputed the defect of memory in old men to the hardness and rigidity of the brain, which hinders it from receiving any durable impression. Retention and Ideas.

Another argument to prove, that in remembrance the mind acts upon something left in the brain by the impressions of sense, is this, that nothing can act but where it is present. The truth of this axiom is acknowledged by Dr Reid, and we believe by all mankind except Dr Priestley and one or two others, whose paradoxes we shall consider afterwards. Now it is confessed, that in recollection at least the mind is active; and therefore it must act, *not* upon an object which has now perhaps no existence, and certainly no immediate existence, *but* upon something left by that object in the brain or sensorium, to which the mind is intimately present.

70 By what means we never confound memory with perception.

But if this be so, we may be asked how it comes to pass that men never confound memory with perception, nor fancy that they perceive things which they only remember? If perception be an inference drawn from certain sensations excited by an impression on the brain, and if remembrance result from the mind's operating upon relicts of those impressions, one would think it natural to suppose, that in both cases we have actual perceptions, though in the one case the perception must be more vivid and distinct than in the other. To this we answer, That previous to all experience, perception and memory are very probably confounded; and that we believe a man brought into the world with all his faculties in their full *natural* perfection, would not instantly be able to distinguish what he remembered from what he perceived. This we know to be the case with respect to imagination, a faculty which strongly resembles memory; for in dreams, and sometimes even in waking reveries, we fancy actually that we perceive things which it is certain we can only imagine. A very short experience, however, would enable this newly created man to make the proper distinction between remembrance and perception. For let us suppose him to be brought into a dark room, and soon afterwards a candle to be introduced. The candle would give him a visible sensation, though not at first the perception of an external object. Let the candle after some time be carried out: the man would retain a visible *idea*, which he might confound with the actual sensation. But if, whilst this idea remained in his mind, the candle were brought back, he would instantly feel a difference between the real sensation and the idea, when both were together present in his mind. And having, in some such manner as we have already described, acquired the power of perceiving external objects by means of his senses, he would soon discover, without any effort of his own, the difference between actual perceptions and the ideas treasured up in his memory.

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(H) Through the whole of this and the preceding chapters, we have taken it for granted, that the sentient principle in man is not material. This is the *common*, and, as shall be shown afterwards, the most *probable* opinion: but whether it be absolutely certain or not, makes no difference on the theories of sensation and perception. These are obviously neither figure nor motion, and therefore not subject to the laws which govern the material world.

Retention and Ideas.

The only remaining difficulty which seems to encumber this theory of remembrance, is, to account for the order of succession in which objects recur to the memory, and to which we give the name of *time*.—But this difficulty will vanish when we have ascertained what *time* is. At present it is sufficient to observe, that our perceptions of external objects remain a certain space of time in the mind; that this time is different, according to the strength and other circumstances of the impression which occasioned the perception; and that traces of those perceptions, i. e. *ideas*, may be recalled after the intervention of other trains of ideas, and at very different intervals. If one look upon a house, and then shut his eyes, the impression which it made upon his mind will not instantly vanish: he can contemplate the house almost as long as he pleases; and, by the help of various associated circumstances, he may recal the idea several years afterwards, and refer it to the original perception.

71 The order of succession in which objects recur to the memory.

72 Brutes have memory, and

Before we dismiss the subject of retention, it may not be improper to take notice of the retentive powers of inferior animals. Aristotle, Locke, Dr Reid, and almost every philosopher of eminence both among the ancients and moderns, have maintained, that inferior animals have memory as well as men; and indeed we do not perceive how the fact can be denied of the more perfect animals, and those with whose operations we are best acquainted. A dog knows his master again after a long absence; a horse will trace back a road which he has but once travelled, often with more accuracy than his rider; and it is well known that many species of singing birds have a capacity to learn tunes from the human voice, and that they repeat the notes again and again, approaching nearer and nearer to perfection, till at last they sing the tune correctly. These phenomena can be accounted for only by supposing, that in the brains of the several animals traces are left by perception, of the same kind with those which perception leaves in the brain of man, and which are the cause or occasion of his remembrance. With respect to this point, the learned author of *Ancient Metaphysics* differs from his master Aristotle. He allows that brutes have imagination, but denies that they have memory: for (says he) " memory necessarily implies a sense of *time*, and what is *first* and *last*; but brutes have no idea of time, or of first and last; and it is certain that they have not consciousness or reflection, by which only they could review their own operations. At the same time he admits, that imagination in the brute serves the purpose of memory in us; for whenever he sees the object that is painted on his *phantasia*, he knows it again, but without any perception of the time when he first saw it." But that a brute, when he sees the object which is painted on his phantasia, should know it *again* without referring it to a former perception, is plainly impossible. The recognisance of any thing consists in a consciousness of its having been perceived before; and nothing more than such recognisance is essential to memory. The author's mistake seems to lie in supposing that memory necessarily implies a sense of some determinate portion of past time; but we surely remember many things of which we can only say that we have formerly perceived them, without being able to ascertain the precise period at which we had such perceptions. A child has the use of memory sooner than he acquires the faculty of speech; but he must have spoken and even reasoned before he can have an accurate notion of time, which, as shall be shown afterwards, arises from comparing the fleeting succession of our own ideas with the permanence of ourselves and other objects. The author's distinction between memory and imagination seems to be on all accounts improper. Aristotle has said, and said truly, that there is memory of *ideas* as well as of sensible objects; meaning by ideas general conceptions or propositions: but this reviver of his philosophy is inclined to say, " that *memory* is only of *ideas*, consequently belongs only to man: and that *imagination* is only of sensible objects, and consequently belongs both to man and brute."—But surely man *remembers* what he has *seen* and *felt* as well as what he has *conceived* or *thought*; and if imagination and memory be properly distinguished by Mr Harris, the reverse of this writer's doctrine must be true, viz. that imagination belongs only to *man*, and memory of sensible objects both to *man* and *brute*.—We can contemplate in imagination the idea of a *centaur* or of a *golden mountain*; but we cannot be said to remember them, for they were never perceived. That a dog can contemplate in his imagination the idea of a *centaur* or of a *golden mountain*, we have not the least reason to suppose; but were he not capable of viewing relicts of sense reposed with him, and referring them to their original causes, he could not possibly recognise his master after a day's absence.

Dr Reid and the same author agree with Aristotle, in thinking it probable that brutes have not reminiscence, or the power of recollection; but there are many well-attested facts which seem to prove the contrary. We shall mention one which fell under our own observation. One of the persons concerned in this work was, when a young man, absent for five months from the house of his father. Upon his return, a dog of that species which is commonly called the *shepherd's cur*, and which had been in the possession of his father only a few months before his departure, gazed at him for a few minutes as at any other stranger. The animal then began to walk round him with looks which soon attracted his notice. This made him call the dog by the name which he bore in the family, and stretch out his hand to caress him, when the creature instantly leaped upon him with all that appearance of attachment which these animals so commonly exhibit upon the return of their master after a few days absence. If this was not recollection, we should be glad to know what it was, for we cannot distinguish it from recollection in men. Indeed, if dogs and some other animals possess, as Aristotle, Locke, and others, allow them to possess, the power of memory, and something of ratiocination; and if, as Dr Reid expressly says*, " they expect events in the same order and succession in which they happened before; it is not conceivable that they can be wholly destitute of reminiscence, or the power of recollection.

73 the power of recollection.

* Essays on the Intellectual Powers of Man

That memory is a faculty of the first importance, cannot be denied; since it is obvious, that, without the power of retaining the ideas and notions which we receive by the senses and other faculties, we never could make any progress in the acquisition of knowledge, but should begin every day, nay every hour, in the same

74 Memory capable of improvement.

same state of ignorance in which we are born. That it is a faculty capable of improvement by exercise, and that there are some methods of exercise better adapted for this purpose than others, has been shown elsewhere. See MEMORY.

CHAP. III. *Of* SIMPLE APPREHENSION *and* CONCEPTION.

75 THE ideas received into the mind by the senses, and treasured up in the memory and imagination, are the original materials of human knowledge. It is by comparing those ideas with one another, or by analyzing them into their first principles, that we acquire all our knowledge in mathematics and philosophy, and indeed all the knowledge which regulates our conduct through life. It must, therefore, be of importance to trace the progress of the mind in her various operations upon these materials; beginning, as she certainly begins, with that which is most simple, and proceeding regularly to those which are more complex and difficult.

76 Now the first operation of the mind about her ideas appears plainly to be that which logicians term *simple apprehension*. Having yesterday observed a *tree* or any other object, if we contemplate the idea of that tree to-day as it remains in the imagination, without comparing it with any other idea, or referring it to any external object, we perform the operation which is called *simple apprehension*. We consider simple apprehension as an *operation*, because the mind in the apprehension of her own ideas is certainly active; she turns them, as it were, round and round, and views them on every side.

77 *Simple apprehension* is a phrase which is commonly taken to be of the same import with the word *conception;* and in the ordinary affairs of life no confusion can arise from an indiscriminate use of the two words: but in this article we think it expedient to employ the phrase *simple apprehension*, to denote the view or contemplation of those ideas only which the mind by sensation has actually received from external objects; and the word *conception* to denote the view, not only of those ideas, but also of such as the mind fabricates to herself. Thus, a man may *conceive* a centaur, but we would not choose to say that he may *apprehend* a centaur: not that there is any impropriety, perhaps, in this last expression; but as there is certainly a difference between *apprehending* the idea of what has been seen or felt, and *conceiving* that which never existed, perspicuity requires that these different operations be expressed by different names.

78 We have said, that the mind may conceive what never existed: and every man may easily satisfy himself that what we have said is true: but though this has been frequently called the creative power of the mind, it has in fact no resemblance to *creation*. The materials of all our most complex and fantastic conceptions are furnished to our hands by sensation and reflection; nor can we form one simple idea which was not originally received by some of our senses from external objects, or, as shall be shown afterwards, one intellectual notion which was not acquired by reflecting on the operations of our own minds. To explain the process of fantastic conception, it is to be observed, that in every sensible object we perceive at once several things, such as *colour*, *figure*, *extension* and *motion* or *rest*, &c. These are the objects of different senses: but they are not, at least by full-grown men, perceived in succession, but all at once; whence it comes to pass that the memory, or the imagination, retains not several distinct and disjointed ideas, but the idea of *one coloured, figured*, and *extended object*. But when we compare various objects, or the ideas of various objects, together, we find that in some respects they agree and in others disagree; i. e. that several objects affect some of our senses in the same way, and other senses differently. Thus one globe is black, and another white; one black substance is circular and hard, and another square and soft. In the first instance, the two globes affect our sense of touch in the same way, and our sense of seeing differently; in the second, the two black substances affect our sense of sight in the same way, and our sense of touch differently.

From observing this difference among objects by means of the different sensations received from them, the mind learns to analyze its original ideas, which are copies of those sensations, into their first principles, and to combine those principles in such a manner as to form complex ideas of objects which were never actually perceived by the senses. Of the simple and unmixed principles which compose those complex ideas, there is not indeed one which was not originally received by some sense; so that the whole difference between complex ideas fabricated by the mind, and those which are the relicts of sensation, consists in the order in which the constituent simple ideas of each are put together. Thus, no man ever saw a mountain of pure gold; and therefore the idea of such a mountain can be in no human mind as a relict of sensation; but we have all seen pieces of gold of different sizes, and we have all seen mountains; and nothing is more easy than to *conceive* a piece of gold extended on all sides to the size of a mountain, and rising out of the earth. Again, though no person ever saw a centaur, yet it is easy to *conceive* the upper parts of a man joined to the breast and shoulders of a horse. In these instances, the complex conceptions are of things which it is in the highest degree probable never had a real existence, and which it is certain we never *perceived* as existing: but the simple ideas of which they are composed are the relicts of actual sensations; for every one has perceived as really existing the body of a horse and the upper parts of a man, and when conceiving a centaur he only perceives them to exist united. That we have not in the imagination one simple and unmixed idea which was not left there as a relict of sense, every man will be convinced who shall try to conceive a simple colour or taste which is totally different from all the colours and tastes, and all the shades and varieties of them, which he has received by sensation; but his simple ideas, though all received from without, he may put together in numberless manners, differing from any order in which he has ever actually perceived the qualities of external objects existing.

Yet even this power of the mind is limited. It is impossible to put together a number of *contrary* and *inconsistent* ideas, in such a manner as to form of them one complex conception. No man, for instance, can conceive 79 This power of conception limited to possible existence.

Of Simple Apprehension and Conception.

conceive a thing to be at once white and black, round and square, hard and soft, in motion and at rest.—Hence it is a maxim among philosophers almost universally received, that though we can conceive many things which never *actually* existed, yet we can form no ideas but of such things as *might possibly exist*. A centaur never existed, but it may be conceived; for it is by no means impossible that the head of a man might be joined to the body of a horse: but black snow cannot be *conceived;* for in the complex idea denoted by the word *snow* whiteness is an essential part, and nothing can be conceived to be both black and white at the same time. From this undoubted fact, that we cannot conceive impossible existence, the power of conception has by some writers in certain instances been made a test of truth. "In every idea is implied (says Dr Price *) the possibility of the existence of its object; nothing being clearer, than that there can be no idea of an impossibility, or conception of what cannot exist." "It is an established maxim in metaphysics (says Hume), that whatever the mind conceives, includes the idea of possible existence; or in other words, that nothing we imagine is absolutely impossible †." In a word, it has been admitted by all philosophers, from Pythagoras to Dr Reid, to be an axiom as evident and undeniable as any in Euclid, that whatever we can distinctly conceive is possible, though many things may be possible, nay may really exist, of which we can form no conception.

* *Review of the principal Questions and Difficulties in Morals.*

† *Essays.*

80
The singular opinion of Dr Reid respecting our power of conception

This axiom has been denied by the author of the Essays on the Intellectual Powers of Man; who affirms, that any two sides of a triangle may be conceived to be equal to the third," as distinctly as "any two sides of a triangle may be conceived to be greater than the third." This assertion from such a man surprised us as much as any paradox which we ever read: for nothing is more certain, than that *we* ourselves can form no conception of a triangle of which two of the sides are only equal to the third. We can, indeed, resolve the proposition into its different parts, and form the distinct and independent ideas of a *triangle*, *two sides*, and *one side;* and we can likewise form the general notion of *equality:* but to combine these ideas and this notion into one individual complex conception, we find to be absolutely impossible. A man who knows nothing of triangles, if such a man there be, might *believe* Dr Reid that it is a figure of which one of its sides is equal to the other two; but such a person would have no *conception* of the *figure itself*, but only a confidence in the doctor's veracity.

81
controverted.

What is it to *conceive* a corporeal thing to exist? Is it not to fancy that we view it on all sides, as what may be seen, or felt, or smelt, or tasted? The doctor, indeed, repeatedly reprobates as the source of much error the notion of ideas as images in the mind; and if ideas be taken as real material figures, he is certainly in the right: But we appeal to the common sense of mankind, whether every person who distinctly *conceives a triangle*, is not at the time conscious that his mind is affected in a similar manner, though not so forcibly, as when he actually views a triangle with his eyes? What other men may feel they know best: but we are as certain that this is the case with respect to ourselves, as we are certain of our own existence. That this affection of the mind is occasioned by some agitation in the brain, of the same kind with that which occasions actual perception, is highly probable; but whatever be the cause, the fact is undeniable.

The doctor's words, indeed, taken by themselves, would lead one to think, that by *conception* he means in this case nothing more than the understanding of the terms of a proposition; but if that be his meaning, there was no room for controversy; as the great philosophers *Cudworth*, *Clarke*, *Price*, and *Hume*, whose opinion he is combating, would have been as ready as himself to allow, that when a man is thoroughly master of any language, he will find no difficulty in understanding the meaning of any particular words in that language, however absurdly these words may be put together. When Dr Price says, that "in every idea is implied the possibility of the existence of its object, nothing being clearer than that there can be no idea of impossibility or conception of what cannot exist," his meaning evidently is, that we cannot mentally contemplate or fancy ourselves viewing any thing corporeal, which we might not actually view with our eyes, or perceive by some other sense (K). This is the true meaning of *conception*, which is something very different from understanding the separate meaning of each word in a proposition.

The learned professor, however, appeals to the practice of mathematicians for the truth of his opinion: and if they be on his side, we must give up the cause; for in no science have we such clear ideas, or such absolute certainty, as in mathematical reasonings. But it is to be observed, that the word *conception* is with

(K) Dr Price may be thought by some to have contradicted in this passage what he had asserted in a former. He is a strenuous advocate for abstract and general ideas even of material objects; but those among the moderns who contend the most zealously for these, contend for them only as conceptions of the mind which can have no possible existence out of it. Were this likewise the opinion of Dr Price, he would certainly have fallen into a direct contradiction; but this is not his opinion. His notion of abstract ideas seems to be the same with that of Plato, who considers ideas not only as the possibilities of existence, but as things actually existing from eternity, uncreated and independent even of the Supreme Mind. That Dr Price carries the matter thus far, we are unwilling to believe; but he certainly considers general ideas as real existences independent of *our* minds, though the immediate objects of our understanding. That in this notion he is mistaken, we shall endeavour to prove in the next chapter. It is enough for our present purpose to have shown that he does not contradict himself; and that he might with great propriety affirm on his own principles, as well as upon the principles of those who admit not of universal ideas, that in every idea is implied the possibility of its object.

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with no propriety applied to *abstract truth*, but to *real* or *possible* existence; nor can we be said to conceive distinctly a *real* or *possible* object, unless we be able to turn it round and round, and view it on all sides.—The faculties which are conversant about *abstract truth* are the judgment and the reason; and truth itself consists in the agreement, as falsehood does in the disagreement, of two or more ideas or terms compared together. If those ideas about which the judgment is to be made can be immediately brought together, without the intervention of a third idea, it is impossible that we should *judge*, or, if Dr Reid will have it so, *conceive* that to be *true* which is *really false*. If the two ideas cannot be immediately brought together, it is impossible that we should form any *judgment* or *conception* at all about their *agreement* or *disagreement*: but we may *suppose* or *admit*, for the sake of argument, that they agree or disagree; and if that supposition conduct to a manifest absurdity, we then *know* that the supposition was false. It is, therefore, perfectly agreeable to the maxim of Price and Hume, that mathematicians should in many cases prove some things to be possible and others impossible, which without demonstration would not have been believed; because if the ideas compared cannot be immediately brought together, no *judgment* previous to the demonstration can be formed of the truth or falsehood of the proposition; and if it concern not real or possible existence, it is a proposition with which *conception* has nothing to do.

"But (says Dr Reid) it is easy to *conceive*, that, in the infinite series of numbers and intermediate fractions, some one number, integral or fractional, may bear the same ratio to another as the side of a square bears to its diagonal." We are so far from thinking this an easy matter, that if the word *conceive* be taken in the sense in which it is used by the philosophers whose opinion he is combating, we must confess that we can form no adequate conception at all of an infinite series. When we make the trial, we can only bring ourselves to *conceive* the real numerical figures 1, 2, 3, &c. or the fractional parts $\frac{1}{2}$, $\frac{1}{4}$, $\frac{1}{8}$, &c.; and even here our *conception* reaches but a small way. We have reason to believe, that minds of a larger grasp can conceive at once more of the series than we can; and that the Supreme Mind conceives the whole of it, if the whole of a mathematical infinity be not a contradiction in terms: but surely no man will say that he can conceive an infinite series as he conceives a centaur, and have an adequate and distinct view of it at once. If, by conceiving that in an infinite series some one number may bear the same ratio to another that the side of a square bears to its diagonal, the doctor only means that such a *supposition* may be made, his observation is not to the purpose for which it is brought; for the question is not about our power to make suppositions of this kind, but about our power to raise in our imaginations an adequate and distinct mental view of possible or impossible existence. "To suppose (says Johnson), is to advance by way of argument or illustration, without maintaining the truth of the position." In this sense a man may *suppose* that in an infinite series there may be some one number which bears the same ratio to another that the side of a square bears to its diagonal: but such a supposition contains in it nothing that is *positive*, which conception always does; it is only admitting, for the sake of argument, a position, of the truth or falsehood of which the person who makes the supposition knows nothing.—He is only talking of ratios as a blind man may talk of colours. A man born blind may be made to comprehend many of the laws of optics, and may make suppositions about colours, and reason from such suppositions to a certain extent, as clearly and justly as one who sees; but will any person say that a man blind from his birth can conceive *red* or *green*? It is much the same with respect to an infinite series. We can follow such a series so far, and may know the ratio by which it increases or decreases, and reason from what we know with the utmost certainty: but no man ever *conceived the whole of an infinite series* as he conceives an individual object; nor can any reasonings upon the nature of it be applied to the question of conceiving impossible existence.

But "mathematicians often require us (says Dr Reid) to conceive things that are impossible, in order to prove them to be so. This is the case in all their demonstrations *ad absurdum*. Conceive (says Euclid) a right line drawn from one point of the circumference of a circle to another, to fall without the circle. I conceive this, I reason from it, until I come to a consequence that is manifestly absurd, and from thence conclude that the thing which I conceived is impossible." If it be indeed true, that Euclid desires his readers to conceive a mathematical circle with a line drawn from one point of its circumference to another, and that line lying without the circle—if he really desires them to form such a complex conception as this, we have no hesitation to affirm, that he requires them to do what is manifestly impossible. The writer of this article has not in his custody any copy of the Elements in the original Greek, and therefore cannot say with certainty what are Euclid's words, nor is it of much importance what they be; for on a question which every man may decide for himself, by looking into his own mind, the authority of Euclid is nothing.—The proposition to which the doctor refers, is the second of the third book; and, in the edition of Simpson, is expressed thus: "If any two points be taken in the circumference of a circle, the straight line which joins them shall fall within the circle." Every mathematician who can form an adequate conception of a circle and a straight line, perceives the truth of this proposition instantly, for it results necessarily from his conception; but he who has not an adequate conception of a circle, *may* stand in need of a demonstration to show him the truth: for it is to be observed, that demonstration does not *make truth*; it only points it out to those who cannot perceive it intuitively, just as a microscope does not make the hairs on a mite's back, but only brings them within the field of vision.

Were a man who never examined a mite through a microscope, and who has no adequate ideas of the insect kingdom, to be asked whether there be hairs on a mite's back? he would probably answer that he did not know, but he could *conceive* no such hairs. In like manner, were a man who has no adequate conception of a mathematical circle, to be asked whether a straight line, which joins any two contiguous points in the circumference, could lie *without* the circle? he would probably

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bably answer that he did not know. Now it is to be remembered, that the reader of the Elements can have no very adequate conception of a circle when he comes to the second proposition of the third book. The definition of a circle was indeed given him in the introduction to the first book; but of that definition he has hitherto had occasion to make very little use, so that his idea of a circle will be little more accurate than that of an illiterate clown, who has no other idea of the figure than what he takes from a halfpenny or a shilling. Dr Reid himself has elsewhere † well observed, that "when a youth of moderate parts begins to study Euclid, every thing at first is new to him. His apprehension is unsteady; his judgment is feeble, and rests partly upon the evidence of the thing, and partly upon the authority of his teacher: but every time he goes over the definitions, the axioms, the elementary propositions, more light breaks in upon him; the language becomes familiar, and conveys clear and steady conceptions." In this state he certainly is when he reads for the first time the second proposition of the third book: his conception of a circle can then be neither clear nor steady. Our young geometrician, however, must allow, that the proposition is either true or false; and if he has read the preceding books with any advantage, he must have clear and steady conceptions of angles and triangles, and be able to demonstrate many of their properties. "Well (says Euclid), though you have no adequate conception of a circle, you are well acquainted with plane angles and triangles, and many of their properties: let us suppose, if that be possible, that my proposition is false, and I will show you that the supposition is absolutely inconsistent with what you know to be demonstrable or self-evident truth." This is all which Euclid can be supposed to require, when, in the words of his excellent translator, he says, "If it (viz. the straight line) do not fall within (the circle), let it fall, if possible, without" He could not possibly desire a man who has an adequate idea of a circle, to form the positive and complex conception of that figure, with a straight line touching two points of the circumference, and yet lying on the outside of the circumference; because all his figures and lines are mere conceptions, and not real material things; and such a request would have been the same thing as if he had said, Conceive what cannot be conceived (L).

† See *Lord Kames's Sketches of the History of Man*; Appendix to the first Sketch on the Sciences.

Of Abstraction and general Ideas.

We have insisted the longer on this point because we think it of the highest importance: for were it indeed true, that we could conceive impossible existence, the consequences would be very melancholy. These consequences it is needless to enumerate. Our readers will perceive, that if we could put together inconsistent ideas of sensible objects, and view them so united as one consistent whole, nothing is clearer than that our faculties would be contrived to deceive us, and we would be doomed to cheerless and universal scepticism.

Chap. IV. *Of* Abstraction *and* general Ideas.

82 Every sensible object and every idea are individual.

Every sensible object is an individual, and differs in many respects from every other object. As such it is perceived by the senses; and ideas being nothing more than relicts of sensation preserved in the imagination or memory, every idea must of course be an individual, as much as the object to which it refers. But all science, whether mathematical, moral, or metaphysical, is conversant about general truths; and if truth consist, as we have already observed, and shall more fully evince afterwards, in the agreement or coincidence of ideas, how, it may be asked, can general truth result from the comparison of particular ideas? To get rid of this difficulty, many philosophers, both ancient and modern, pretend that the mind is furnished with *general ideas*, from a comparison of which result general propositions applicable to many individuals. Philosophers, indeed, have differed in opinion respecting the source of those ideas, some of the ancients deriving them immediately from the Supreme Mind to the human, whilst almost all the moderns say that they are framed by abstraction, and therefore call them *abstract ideas*.

83 The doctrine of abstract ideas stated, and

The doctrine of *abstract* ideas has been so fairly stated, and, in our opinion, so completely overturned, by Bishop Berkeley, that we shall content ourselves with abridging what he has said on the subject, and obviating

(L) Principal Campbell, treating of the commonly received doctrine of abstraction, and having shown, that though Locke has in one passage of his immortal work expressed himself on the subject in terms unintelligible, his sentiments on the whole differed little from those of Berkeley and Hume, adds, "Some of the greatest admirers of that eminent philosopher seem to have overlooked entirely the preceding account of his sentiments on this subject; and, through I know not what passion for the paradoxical (I should rather say the impossible and unintelligible), have shown an amazing zeal for defending the propriety of the hasty expressions which appear in the passages formerly referred to. Has not the mind of man (say they) an unlimited power in moulding and combining its ideas? The mind, it must be owned, hath an unlimited power in moulding and combining its ideas. It often produces wonderful forms of its own out of the materials originally supplied by sense; forms indeed of which there is no exemplar to be found in nature:—centaurs and griffins,

Gorgons and hydras, and chimeras dire.

But still it must not attempt absolute impossibilities, by giving to its creature contradictory qualities. It must not attempt to conceive the same thing to be black and white at the same time; to be no more than three inches long, and yet no less than three thousand; to conceive two or more lines to be both equal and unequal; the same angle to be at once acute, obtuse, and right;" or, we may add, the two sides of a triangle to be not greater than the third. See *Philosophy of Rhetoric*, vol. ii. p. 108, &c.

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obviating some cavils which have lately been urged against his reasoning. "It is agreed on all hands (says that learned and ingenious prelate *), that the qualities or modes of things do never really exist each of them apart by itself and separated from all others; but are mixed, as it were, and blended together, several in the same object. But, we are told the mind being able to consider each quality singly, or abstracted from those other qualities with which it is united, does by that means frame to itself abstract ideas. For example: There is perceived by sight an object extended, coloured, and moved: this mixed or compound idea, the mind resolving into its simple constituent parts, and viewing each by itself exclusive of the rest, does frame the abstract ideas of extension, colour, and motion. Not that it is possible for colour or motion to exist without extension; but only that the mind can frame to itself by *abstraction* the idea of colour exclusive of extension, and of motion exclusive of both colour and extension. Again, The mind having observed, that in the particular extensions perceived by sense, there is something common and alike in all, and some other things peculiar, as this or that figure or magnitude, which distinguish them from one another; it considers apart, or singles out by itself, that which is common, making thereof a most abstract idea of extension, which is neither line, surface, nor solid, nor has any figure or magnitude, but is an idea entirely prescinded from all these. So likewise the mind, by leaving out of the particular colours perceived by sense that which distinguishes them one from another, and retaining that only which is common to all, makes an idea of colour in abstract, which is neither red, nor blue, nor white, nor any other determinate colour. And as the mind frames to itself abstract ideas of qualities or modes, so does it by the same precision or mental separation attain abstract ideas of the more compounded beings, which include several coexistent qualities. For example: The mind having observed that *Peter*, *James*, and *John*, resemble each other in certain common agreements of shape and other qualities, leaves out of the complex or compounded idea it has of *Peter*, *James*, and any other particular man, that which is peculiar to each, retaining only what is common to all, and so makes an abstract idea wherein all the particulars equally partake, abstracting entirely from and cutting off all those circumstances and differences which might determine it to any particular existence. After this manner, it is said, we come by the abstract idea of *man*, or, if you please, humanity or human nature, in which, it is true, there is included colour, because there is no man but has some colour; but then it can be neither *black*, nor *white*, nor any *particular* colour, because there is no one particular colour wherein all men partake. So likewise there is included stature; but then it is neither tall stature, nor low stature, nor middle stature, but something abstracted from all these; and so of the rest. Moreover, there being a great variety of other creatures that partake in some parts, but not all, of the complex idea of *man*; the mind, leaving out those parts which are peculiar to man, and retaining those only which are common to all the living creatures, frameth the idea of *animal*; which abstracts not only from all particular men, but also from all birds, beasts, fishes, and insects. The constituent parts of that abstract idea of animal, are body, life, sense, and spontaneous motion. By *body*, is meant body without any particular shape or figure, there being no one shape or figure common to all animals, without covering either of hair or feathers or scales, &c. and yet not naked; hair, feathers, scales, and nakedness, being the distinguishing properties of particular animals, and for that reason left out of the *abstract idea*. Upon the same account, the spontaneous motion must be neither walking, nor flying, nor creeping: it is nevertheless motion; but what that motion is, it is not easy to conceive.

84 controverted; and

"Whether others have this wonderful faculty of *abstracting their ideas* (continues the bishop), they best can tell; for myself, I find indeed that I have a faculty of imagining or representing to myself the ideas of those particular things which I have perceived, and of variously compounding and dividing them. I can imagine a man with two heads, or the upper parts of a man joined to the body of a horse. I can consider the hand, the eye, the nose, each by itself abstracted or separated from the rest of the body. But then, whatever hand or eye I imagine, it must have some particular shape, and some particular colour.—Likewise the idea of man that I frame to myself, must be either of a white, or a black, or a tawney, a straight or a crooked, a tall or a low, or a middle-sized man. I cannot by any effort of thought conceive the abstract idea above described. To be plain, I own myself able to abstract in one sense, as when I consider some particular parts or qualities separated from others with which, though they are united in some objects, yet it is possible they may really exist without them. But I deny that I can abstract one from another, or conceive separately those qualities which it is impossible should exist so separated; or that I can frame a general notion by abstracting from particulars in the manner aforesaid; and there are grounds to think most men will acknowledge themselves to be in my case."

85 shown to be absurd.

To think this, there are indeed such good grounds, that it is probable some of our readers, little conversant with the writings of modern metaphysicians, are by this time disposed to suspect, that the bishop in his zeal may have misrepresented the doctrine of *abstraction;* as no man in his senses, who is not perverted by some darling hypothesis, can suppose himself capable of tagging together such monstrous inconsistencies, as magnitude which is neither large nor small, and colour which is neither white, red, green, nor black, &c. But that the ingenious prelate, in his account of this process of *looping* and *pruning*, as Mr Harris contemptuously, but most properly, terms it, has not exaggerated in the smallest degree, is apparent from the following account of *abstraction* given by Mr Locke. "*Abstract ideas* (says that writer) are not so obvious or easy to children, or the yet unexercised mind, as particular ones. If they seem so to grown men, it is only because by constant and familiar use they are made so; for when we nicely reflect upon them, we shall find that general ideas are fictions and contrivances of the mind that carry difficulty with them, and do not so easily offer themselves as we are apt to imagine. For example, does it not require some pains and skill to form the general idea of a triangle.

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triangle (which is yet none of the most abstract, comprehensive, and difficult)? for it must be neither oblique nor rectangle, neither equilateral, equicrural, nor scalenon, but *all and none of these at once.* In effect, it is something imperfect that cannot exist, an idea wherein some parts of several different and *inconsistent* ideas are put together." "Surely (to use the words of Principal Campbell *) the bare *mention* of this hypothesis is equivalent to a confutation of it, since it really confutes itself." But if any man has the faculty of framing in his mind such an idea of a triangle as is here described, it would be vain in us to dispute with him; for we are possessed of no such faculty, and therefore would fight on unequal terms. All we have to desire is, that the reader would fully and certainly inform himself whether he has such an idea or not; and this can be no hard task to perform. What is more easy for any one than to look a little into his own thoughts, and there try whether he has, or can attain to have, an idea of *colour* separated from all *extension;* of *extension*, which is neither *great* nor *small;* of *taste*, which is neither *sweet* nor *bitter*, nor *acid*, nor *agreeable*, nor *disagreeable;* or the general idea of a triangle, which is neither *oblique* nor *rectangle, equicrural, equilateral,* nor *scalenon, but all and none of these at once* (M)?

* *Philosophy of Rhetoric.*

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Abstract conceptions the same with abstract ideas.

Dr Reid having denied that there are or can be in the mind any *ideas* of sensible objects, rejects of course the doctrine of *abstract general ideas*, whilst he maintains in fact the same thing, only substituting the word *conception* for the word *idea*. "What hinders me (says he) from attending to the whiteness of the paper before me, without applying that colour to any other object?" We know nothing indeed which can hinder any man from performing this operation, which is daily and hourly performed by infants; but will the doctor say, that he can attend to colour, or conceive it, abstracted from the paper and every other surface? We are persuaded he will not, though he immediately adds, the "whiteness of this individual object is an *abstract conception*." Now we should rather have thought, that, consistent with his own notions of colour, he would have called the whiteness of the paper a *concrete quality*, and his own conception of it a *particular* and *concrete conception*. If he conceives the whiteness as separated from the paper, it is no longer the whiteness of that individual object: and he must either conceive it as abstracted from *all* objects, which is plainly impossible: or he must conceive it as inhering in some other object, and then neither the quality of whiteness, nor his conception of it, is abstract in general, but concrete and particular. He affirms, however, "that in abstraction, strictly so called, he can perceive nothing that is difficult either to be understood or practised." This is going much farther into the doctrine than Mr Locke went; for he owned that there was much difficulty in it. Let us see how it becomes so easy to Dr Reid. "What can be more easy (says he) than to distinguish the different attributes which we know to belong to a subject? In a man, for instance, to distinguish his size, his complexion, his age, his fortune, his birth, his profession, and twenty other things that belong to him." All this indeed, and much more, we can do with the utmost ease; but this is not abstraction, strictly so called, nor any thing like abstraction. We distinguish the size, the complexion, the age, &c. of the man, from *one another:* but still we conceive them all as *his* qualities; nor is it possible, at least for us, *to abstract them from him*, without conceiving them as the qualities of some *other* man; so that *our* conceptions are all concrete and particular. "It ought likewise to be observed (says the professor), that attributes may with perfect ease be distinguished and *disjoined* in our conception, which cannot be *actually separated* in the subject." They may be so in his conception, but certainly not in ours; for *we* can conceive nothing which may not actually exist. "Thus (continues he) I can in a body distinguish its solidity from its extension, and its weight from both. In extension, I can distinguish length, breadth, and thickness; yet none of these can be separated from the body, or from one another. It is therefore *certain*, that attributes, which in their nature are absolutely inseparable from their subject, and from one another, may be disjoined in our conception; one *cannot exist* without the other, but one *can be conceived* without the other." So far is this from being a matter of *certainty*, that in every possible sense in which we can understand the word *conception*, it appears to us as evidently *false*, as that *three* and *two* are equal to *nine*. It is indeed not difficult to distinguish *in* a body its solidity from its extension, and its weight from both: but can we distinguish them *out* of the body? or, to speak in plain language, can we conceive *solidity* as separated from *all extension* and *all weight?* Unless this can be done, and by *us* it cannot be done, there is no *abstraction strictly so called.* It is indeed easy to conceive *solidity* or *extension* abstracted from *any one* individual object: but how is it done? Why by transferring your attention to some other *individual object.* Thus, we can easily conceive *solidity* or *extension* separated from a guinea, for instance; but it is only by transferring our thoughts to another body, *a piece of silver*, or a *ball of lead*, &c. and our conceptions in both cases are *particular* and *concrete*.

As we think this opinion of Dr Reid's respecting ABSTRACTION both ill-founded and of dangerous consequences, we have expressed our dissent from it in strong terms; and in doing so we have only followed the example set us by himself when dissenting from the theories of Hume and Berkeley. But we are so thoroughly

(M) "If such an extraordinary faculty (abstraction) were possible, I cannot for my part conceive what purpose it could serve. An idea hath been defined by some logicians, the form or resemblance of a thing in the mind; and the whole of its power and use in thinking is supposed to arise from an exact conformity to its archetype. What then is the use or power of that idea, to which there neither is nor can be any archetype in nature, which is merely a creature of the brain, a monster that bears not the likeness of any in the universe?" *Philosophy of Rhetoric*, vol. ii. p. 110.

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roughly convinced that the doctor's acuteness is superior to our own (M), that we are not without our fears that we may have mistaken his meaning. We are conscious that we have not wilfully misrepresented it; and to enable our readers to judge for themselves between him and us, we shall lay before them his definition of *general conceptions* in his own words.

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That there are in every language *general terms*, is known to all mankind; for such are all substantives, proper names excepted; and all adjectives. But "it is impossible (says the doctor*) that words can have a general signification, unless there be conceptions in the mind of the speaker and of the hearer, of *things* (N) that are *general*. It is to such that I give the name of *general conceptions*: and it ought to be observed, that they take this denomination, not from the act of the mind in conceiving, which is an individual act; but from the object or thing conceived, which is general." Now, whatever is conceived, must be either *external* to the mind, or *present* with it. But the doctor himself acknowledges, "That all the objects we perceive are individuals. Every object of sense, of memory, or of *consciousness*, is an individual object. All the good things we enjoy or desire, and all the evils we feel or fear, must come from individuals; and I think I may venture to say, that every creature which God has made in the heavens above, or in the earth beneath or in the waters under the earth, is an individual." If this be so, and no man can call it in question, it is obvious that we can have no *general* conception of any thing *external*. The *act* of conceiving is *an individual act*; and therefore the only thing which can be *general*, must be something present with the mind, and different from the *mere act of conceiving*: But what can this be, if not what

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Berkeley and others call an *idea*? and how can we have an *idea* of which we are not *conscious*? yet every thing of which we are conscious Dr Reid himself acknowledges to be an *individual*.

But if the doctrine generally received respecting abstract ideas be so very absurd as it has appeared in our representation, how comes it to be so prevalent among the acutest philosophers? To this we answer, that those philosophers have certainly in this instance been imposed upon by the structure of language. Every adjective and every substantive, proper names excepted, are words of general signification; and all science is conversant about general truth; but as words are said to be significant, not of things, but of ideas; and as truth results from the agreement or coincidence of ideas; it has been hastily supposed, that without general ideas there could have been neither general terms nor general truth. This is plausible, but it is not solid. Every object which affects our senses is an individual object; but we perceive that two or more objects which affect some of our senses very differently, affect others of them in precisely the same way. Thus, the paper upon which one writes, the snow which he perceives from his window, and the milk which he may use at breakfast, affect his senses of touch and taste very differently, but they present the same appearances to his eye. This diversity in the one case he believes to proceed from different powers or qualities in the several objects; and the sameness of appearance in the other, from similar qualities in these objects. To the similar qualities, though he can frame no idea of them abstracted from every individual object, he gives one common name; and calls every object which presents the same appearance to his eye that snow does, a *white* object; where the word *white* does not stand for an abstract idea, but for a quality inherent in one or more objects. Hence the origin of adjectives in language, which denote more than can be expressed by any class of substantives; for every adjective, besides the power of a name, includes in itself the force of a conjunction. See GRAMMAR.

The other class of general terms comprehends substantives; of which the origin is as follows: The objects about which we have occasion to speak or write are so numerous and so fluctuating, that if every individual had a proper name, a complete language could never be formed. But as there are not perhaps in nature two objects that appear to us similar in all respects, so are there not in nature two objects which affect *all* our senses differently. The mind, therefore, either actually perceiving two or more objects at once, or contemplating the *ideas* left by two or more objects in the memory, perceives, by its intellectual power, in what respects they agree and in what they disagree. If the agreement be striking, and in more qualities than one, it combines the several individuals into one class or species, giving to the whole a common name, which equally denotes the species and every individual belonging to it. Thus, observing that Peter, James, and John, agree in having the same erect form, in walking on two legs, in having hands, &c. and in being endowed with reason, we combine these three, and all other individuals which we perceive to agree in the same striking and important qualities, into one species, to which we give the name of *man*—a word which equally denotes the whole species and every individual of it. Again, Contemplating several figures, which all agree in the circumstance of being bounded by three straight lines meeting one another so as to form three angles, we call the whole class of figures and each individual by the name of *triangle*—though it may be impossible to contemplate any number of triangles without perceiving that all the angles of one are acute; that one angle of another is a right angle; and that in the third there is one angle obtuse; but the word *triangle*, unless it is limited in its signifiation by the addition of an adjective, is equally expressive of an acute-angled triangle, a right-angled triangle, and an obtuse-angled triangle. By thus arranging individuals according to their most conspicuous qualities, we may combine all the objects existing into so many classes or species, which shall be afterwards known by as many names; but of each species we neither have, nor can have,

(M) Notwithstanding this declaration, which is made with the greatest sincerity, we do not apprehend that we are guilty of presumption when we examine the doctor's opinions. Berkeley and Hume were certainly as acute as any metaphysician who has succeeded them; yet their opinions have been canvassed without ceremony, and to much advantage. *Aliquando bonus dormitat Homerus.*

(N) He tells us soon afterwards, that there are *no things general.* How is the one passage to be reconciled with the other?

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have, any other idea than that of a multitude of similar individuals.

As our acquaintance with nature enlarges, we discover resemblances, striking and important, between one species and another, which naturally begets the notion of a higher class called a *genus*. From comparing man with beasts, birds, fishes, and reptiles, we perceive that they are all alike possessed of life, or a principle of sensation and action, and of an organized body: hence we rank them all under a higher class or genus, to which we give the name of *animal;* which equally denotes the whole *genus*, each species comprehended under the *genus*, and every *individual* of every *species*. Thus, *animal*, is a *genus; man, beast, bird*, are so many *species* comprehended under that *genus;* and *Peter, James*, and *John*, are *individuals* of the species *man*. *Peter, James*, and *John*, are proper names, denoting each an *individual; man, beast, bird*, are *specific* terms, denoting each a *whole species* comprising many *individuals;* and *animal* is a *general term*, because it denotes a *whole genus*, comprehending under it *several species*, of which each consists of *many individuals;* and the general term denotes either the whole *genus*, all the *species*, or any *individual* of all the species. This is the whole mystery of *abstraction:* they are merely *terms*, that in strictness of speech are *general* and *abstract;* and even those are general only as *signs*, of which the full signification cannot always be represented by any conceivable *idea*.

89 Names and ideas often used as mere signs,

"It is a received opinion (says Bishop Berkeley), that language has no other end but the communicating of our ideas, and that every significant name stands for an idea. This being so; and it being withal certain, that names, which yet are not thought altogether insignificant, do not always mark out particular conceivable ideas; it is straightway concluded that they stand for abstract notions. That there are many names in use amongst speculative men, which do not always suggest to others determinate particular ideas, is what nobody will deny: and a little attention will discover, that it is not necessary, even in the strictest reasonings, that significant names, which stand for ideas, should every time they are used excite in the understanding the ideas they are made to stand for. In reading and discoursing, names are for the most part used as letters in algebra; in which, though a particular quantity be marked by each letter, yet to proceed right, it is not requisite that in every step each letter suggest to our thoughts that particular quantity it was appointed to stand for." The same thing is true of ideas, which as well as names are often used merely as signs representing a whole class; and on that account they may be called *general*, though every idea is in itself strictly particular. Thus, "An idea, which considered in itself is particular, becomes general by being made to represent or stand for all other particular ideas of the same sort. To make this plain by an example, suppose a geometrician is demonstrating the method of cutting a line in two equal parts: He draws, for instance, a black line of an inch in length: this, which in itself is a particular line, is nevertheless, with regard to its signification, general; since, as it is there used, it represents all particular lines whatsoever: so that what is demonstrated of it is demonstrated of all lines, or, in other words, of a line in general. And as that particular line becomes general by being made a sign, so the *name* line, and the *idea* of a line in the imagination, either of which taken absolutely is particular, by being signs are made general likewise. And as the former owes its generality, not to its being the sign of an abstract or general line, but of all particular right lines that may possibly exist; so the latter, the name and the idea, must be thought to derive their generality from the same cause, namely, the various particular lines which each of them indifferently denotes." Again, When one demonstrates any proposition concerning triangles, it is to be supposed that he has in view to demonstrate an universal truth; yet the particular triangle which he considers must be either equilateral, isosceles, or scalenon; for a plain triangle, which is none of these, can neither exist nor be conceived. But whether it be of this or that sort is of no importance, as any of them may equally stand for and represent all rectilineal triangles, and on that account be denominated *universal*.

This doctrine respecting names and ideas being used merely as *signs*, has been adopted by almost every subsequent philosopher; and by Principal Campbell it has been illustrated with perspicuity and acuteness every way worthy of the author of the Dissertation on Miracles. "In confirmation of this doctrine (says he *), it may be observed, that we really think by *signs*, as well as speak by them. All the truths which constitute science, which give exercise to reason, and are discovered by philosophy, are general; all our ideas, in the strictest sense of the word, are particular. All the particular truths about which we are conversant are properly historical, and compose the furniture of memory. Nor do I include under the term *historical* the truths which belong to natural history; for even these too are general. Now, beyond particular truth or historical facts, first perceived and then remembered, we should never be able to proceed one single step in thinking any more than in conversing, without the use of signs.

* *Philosophy of Rhetoric.*

"When it is affirmed that *the whole is equal to all its parts*, there cannot be an affirmation which is more perfectly intelligible, or which commands a fuller assent. If, in order to comprehend this, I recur to ideas, all that I can do is to form a notion of some individual whole, divided into a certain number of parts of which it is constituted; suppose of the year, divided into the four seasons. Now all that I can be said to discern here is the relation of equality between this particular whole and its component parts. If I recur to another example, I only perceive another particular truth. The same holds of a third and of a fourth. But so far am I, after the perception of ten thousand particular similar instances, from the discovery of the universal truth, that if the mind had not the power of considering things as signs, or particular ideas as representing an infinity of others, resembling in one circumstance though totally dissimilar in every other, I could not so much as conceive the meaning of an universal truth. Hence it is that *some ideas*, to adopt the expression of Berkeley, *are particular in their nature, but general in their representation*."

90 which, though particular in themselves serve to demonstrate general truths; because

But if in universal propositions, ideas particular in themselves be used only as the signs of others, it may be demanded, how we can know any proposition to be true of all the ideas which are represented by the sign?

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sign? For example, having demonstrated that the three angles of an isosceles rectangular triangle are equal to two right ones, how can we conclude that this affection therefore agrees to all other triangles which have neither a right angle nor two equal sides? To this question Bishop Berkeley and Principal Campbell give the following answer: Though the idea we have in view whilst we make the demonstration be that of an isosceles rectangular triangle, whose sides are of a determinate length, we may yet be certain that the demonstration extends to all other rectilineal triangles of what sort or bigness soever; for this plain reason, that neither the equality nor determinate length of the sides, nor the right angle, are at all concerned in the demonstration. It is true, the idea or diagram we have in view includes all these particulars; but then there is not the least mention made of them in the proof of the proposition. It is not said the three angles are equal to two right angles, *because* one of them is a *right angle*, or because the sides comprehending it are of equal length; which sufficiently shows that the right angle might have been oblique and the sides unequal; and for all that the demonstration have held good. In every one of Euclid's theorems, a particular triangle, and a particular parallelogram, and a particular circle, are employed as signs to denote all triangles, all parallelograms, and all circles. When a geometrician makes a diagram with chalk upon a board, and from it demonstrates the property of a straight-lined figure, no spectator ever imagines that he is demonstrating a property of nothing else but that individual white figure, five inches long, which is before him.—Every one is satisfied that he is demonstrating a property of all of that order, whether more or less extensive, of which it is both an example and a sign; all the order being understood to agree with it in certain characters, however different in other respects. Nay, what is more, the mind with the utmost facility extends or contracts the representative power of the sign as the particular occasion requires. Thus the same equilateral triangle will with equal propriety serve for the demonstration, not only of a property of all equilateral triangles, but of a property of all isosceles triangles, or even of a property of all triangles whatever. Nay, so perfectly is this matter understood, that if the demonstrator in any part should recur to some property belonging to the particular figure he hath constructed, but not essential to the kind mentioned in the proposition, and which the particular figure is solely intended to represent, every intelligent observer would instantly detect the fallacy: So entirely for all the purposes of science doth a particular serve for a whole species or genus. Now, why one *visible* individual should in our reasonings serve without the smallest inconvenience as a sign for an infinite number, and yet one *conceivable* individual, or a particular idea of imagination, should not be adapted to answer the same end, it will, we imagine, be utterly impossible to say (N).

It must, however, be confessed, that there is a considerable difference in kind, between *ideas* used as signs and the *general* terms of any language. Amongst all the individuals of a species, or even of the highest genus, there is still a natural connexion, as they agree in the specific or generic character; and when the mind makes use of any positive idea as the sign of the species or genus, that idea appears in the imagination as an exact resemblance of some one individual. But the connexion which subsists between words and things, or even between words and ideas, is in its origin arbitrary; and yet its effect upon the mind is much the same with that of the natural connexion between ideas and things. For having often had occasion to observe particular words used as signs of particular things, and specific terms used as signs of a whole species, we contract a habit of associating the sign with the thing signified, insomuch that either being presented to the mind necessarily introduces or occasions the apprehension of the other. Custom in this instance operates precisely in the same manner as natural resemblance in the other; so that certain sounds, and the ideas of things to which they are not naturally related, come to be as thoroughly linked in our conceptions as the ideas of things and things themselves. Nay, so completely are they linked together, that we often use, through long chains of reasoning, certain sounds or words, without attending at all to the ideas or notions of which they are signs. "I believe (says the author of *A Treatise on Human Nature*), that every one who examines the situation of his mind in reasoning will agree with me, that we do not annex distinct and complete ideas to every term we make use of; and that in talking of *government*, *church*, *negotiation*, *conquest*, we seldom spread out in our minds all the simple ideas of which the compound notions signified by these terms are composed. It is, however, observable, that notwithstanding this imperfection, we may avoid talking nonsense on these subjects, and may perceive any repugnance among the ideas as well as if we had a full comprehension of them." This remark generally holds true; but then it is to be observed, that all the words used as signs, and which yet do not denote any one conceivable determinate *idea*, must be capable of definition. Thus, in matters that are perfectly familiar, in simple narration, or in moral observations on the occurrences of life, a man of common understanding may be deceived by specious falsehood, but is hardly to be gulled by downright nonsense or a repugnance

(N) Were it possible to frame an *abstract general idea* of a triangle, which is neither equilateral, isosceles, nor scalenon, even *that idea* must be used merely as a sign as much as any particular triangle whatever; and the question might still be asked, How we can know any proposition to be true of all the triangles represented by the sign? For example: having demonstrated that the three angles of an ideal triangle, which is neither equilateral, isosceles, nor scalenon, are equal to two right angles, how can we conclude that this affection agrees to triangles which are equilateral, &c.? To this question it is not easy to conceive what answer could be given other than that of Berkeley and Campbell, in the case of using particular and conceivable triangles as signs.

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nance of ideas. Almost all the possible applications of the terms (in other words, all the acquired relations of the signs) have become customary to him. The consequence is, that an unusual application of any of them is instantly detected: this detection breeds doubt, and this doubt occasions an immediate recourse to *definition;* which, proceeding through species and genera, resolves complex terms into others less complex, till it ends at last in simple ideas and relations, which can neither be defined nor misunderstood (O). See LOGIC.

91 it is not the *matter* but the *power* of the sign that is regarded by the mind.

Thus then we see, that though there are no ideas, properly speaking, general and abstract, a man may, by *terms* and *particular* ideas, used as *signs*, arrive at the knowledge of general truth. In neither case is it the *matter*, if we may be allowed the expression, but the *power* of the sign that is regarded by the mind. We find, that even in demonstrative reasonings, signs the most arbitrary, or mere symbols, may be used with as little danger of error as ideas or natural signs. The operations both of the algebraist and arithmetician are strictly of the nature of demonstration. The one employs as *signs* the letters of the alphabet, the other certain numerical characters. In neither of these arts is it necessary to form ideas of the quantities and sums signified; in some instances it is even impossible without resolving the quantity or sum into parts, in a manner analogous to definition; and then the mind comprehends not the whole quantity or number at once, but the several parts of which it is composed, which it connects (P) by the relation of junction or addition. Yet without this resolution, the equations and calculations carried on by means of the letters and figures significant of the whole quantity or the whole sum, are not the less accurate or convincing. And so much for *abstraction*, *generalization*, and the power of *signs*, whether *natural* or artificial.

CHAP. V. *Of the* ASSOCIATION *of* IDEAS.

92 A continued train of thought in the mind.

EVERY man whilst awake is conscious of a continued train of thought spontaneously arising in his mind and passing through it; nor could a single now or instant be pitched upon in which some idea is not present in his memory or imagination. No one idea, however, unless detained by a voluntary exertion of the mind, or unless productive of intense pleasure or pain, remains long in the imagination; but each hastens off the stage to make way for another, which takes its turn and is succeeded by a third, &c. We are not to imagine that this train of thought is altogether fortuitous and incoherent. "It is evident (says Mr Hume*), that there is a principle of connexion between different thoughts or ideas of the mind; and that, in their appearance to the memory or imagination, they introduce each other with a certain degree of method and regularity. In our more serious thinking or discourse this is so observable, that any particular thought which breaks in upon the regular track or chain of ideas is immediately remarked and rejected. Even in our wildest and most wandering reveries, nay, in our very dreams, we shall find, if we reflect, that the imagination ran not altogether at adventures, but that there was still a connexion upheld among the different ideas which succeeded each other Were the loosest and freest conversation to be transcribed, there would immediately be observed something which connected it in all its transitions: Or, where this is wanting, the person who broke the thread of discourse, might still inform you, that there had secretly revolved in his mind a succession of thoughts, which had gradually led him from the subject of conversation. Among different languages, even where we cannot suspect the least connexion or communication, it is found, that words expressive of ideas the most compounded, do yet nearly correspond to each other; a certain proof that the simple ideas comprehended in the compound ones, were bound together by some universal principle, which had an equal influence on all mankind."

* Essays.

Association of Ideas.

93 Principles of association.

That these observations are well founded, every man may be satisfied by looking attentively into his own thoughts; but when the author reduces the principles of this association of ideas to *three*, viz. *resemblance*, *contiguity* in time and place, and *cause* or *effect*, he certainly contracts them within too narrow a compass. That these principles often serve to connect ideas, will not indeed be denied. A picture leads our thoughts to the original: the mention of one apartment in a building introduces an inquiry or discourse concerning the others: and if we think of a wound, we can hardly forbear reflecting on the pain which follows it. But surely ideas sometimes succeed each other without *resemblance*, without *contiguity* in time or in place, and without being connected by the relation of a *cause* to its *effect*. Besides all this, there are other associations than of *ideas*. Ideas are associated with passions and emotions, and passions and emotions are associated together. A particular idea is associated with a proper name, and often with the general name of the species. General conceptions, such as those which Mr Locke calls mixed modes (see MODE), are associated with signs both audible and visible, and signs are associated with each other. Surely virtue, as it consists in action and intention, does not resemble the *sound* virtue, is not *contiguous* to it in time or in place, and is neither its *cause* nor its *effect;* nor is it conceivable, that the arbitrary signs of different things should have any natural relation to one another.

But were the enumeration complete, the bare mention of these principles does not account for the phenomena:

(O) For a farther view of this subject, see some excellent observations on the common doctrine concerning abstraction by Professor Dugald Stewart of Edinburgh. *Elements of the Philosophy of the Human Mind.*

(P) No man, we think, will pretend that he can perceive at one view a million of individual men, or that he can imagine or conceive at once a million of ideal men: yet he may divide the million into parts, which, in the one case may be easily viewed, and in the other may be easily conceived, in succession. Thus, 100 + 100 + 100, &c.

Association of Ideas.

nomena: For, granting the fact, it may still be asked, Why does a picture lead our thoughts to the original; or the mention of one apartment in a building introduce an inquiry concerning the others? To these questions our author has given no answer; nor are we acquainted with any writer who can be said to have attempted it, except Dr Hartley and his ingenious editor. There may be some of our readers whom the names of these men will prejudice against their theory: but, doubtless, the greater part are willing to adopt truth, or to examine an ingenious speculation, from whatever quarter it comes. To such as feel themselves otherwise disposed, we beg leave to say, that if they allow the name of *Priestley* to disgust them at what follows, they will furnish him with a new proof of the truth of the doctrine which they reject.

How they operate.

That *ideas* should be associated together, seems to be inevitable from the manner in which the mind acquires them. All our ideas, properly speaking, are of sensible objects, and by far the greater part of them of *visible* objects. But every sensible object conveys at once various sensations and perceptions to the mind, which appear not only united in fact, but inseparable in imagination. Thus, when a man looks at any particular object, a tree for instance, he perceives the *trunk*, *branches*, *leaves*, *size*, *shape*, and *colour*, &c. of the whole at *once*: he does not first perceive the *figure* of the trunk, then its *size*, then its *colour*, then the *branches*, &c. all in succession: but a perception of the *whole* is conveyed to the mind by one simultaneous impression, (Q). We have already seen, that the senses, in fact, convey nothing to the mind but their respective sensations; and that the perception of the external object instantly follows the sensation. We have likewise seen, that sensation is occasioned by some impression, concussion, or vibration, given to the nerves and brain, and by them communicated to the mind or percipient being. We have likewise seen, that memory depends as much upon the brain as original sensation, and is always attended or occasioned by similar concussions or vibrations, &c. These are facts proved by universal experience, and which, we believe, no thinking man has ever called in question. It follows, therefore, that every actual sensation must leave some effect in the brain, either an actual print, which seems to be impossible, or a tendency to vibrate or be agitated in the same way as when the original impression was made. This being the case, it is natural to conclude, that when any part of the original perception is revived in the memory, the whole perception should be revived at once, so as that we cannot have an idea of the trunk of a tree without perceiving the ideas of the branches associated with it. This is indeed not merely natural, but the contrary seems to be impossible; for as the original agitation or vibration was occasioned by the whole tree, it is evident, that whatever effect or tendency that agitation or vibration left behind it, must be left by the whole vibration, and therefore be equally related to the whole tree.

But no object stands single in nature. When we view a tree, or any thing else, we always notice, however transiently, the field where it grows and the objects around it. These two leave effects in the brain at the same time that the tree does so; and therefore make their appearance with it in the memory or imagination: but if the tree was the object to which we principally attended during the actual sensation, the idea of it will be much more vivid than the idea of its adjuncts, and remain much longer in the imagination or memory; because the original sensation by which it was perceived, was struck much deeper than the sensation by which its adjuncts were perceived. All this must be intelligible to every one who attends to what we have already said of sensation, perception, and memory.

Thus we see why a picture leads our thoughts to the original, and why the mention of one apartment in a building introduces an inquiry concerning the others. It is not merely because the picture *resembles* the original, and because the apartments of a building are *contiguous*. Between a plain surface, variously coloured and shaded, and the contour of the human face, there is certainly very little real resemblance, as any man may be convinced who places his eye within six inches of a good picture. But the painter, having by his skill in perspective, contrived to lay his colours on the plain canvas in such a manner as that they reflect the same rays of light with the original, provided the spectator stand at the proper distance; these rays proceeding from the picture fall upon the eye in the same direction, and therefore give to the nerves and brain the very same impulse which was given by the original. When one apartment of a building is mentioned, we inquire concerning the others from the very same cause that, when we think of the trunk of a tree which we have seen, we cannot avoid thinking likewise of its branches.

95
Association gives meaning to the words of language;

But the principle of association takes place among things not naturally connected, as the apartments of a

(Q) This is certainly the case with adults, but it may be doubted whether it be so with very young children. It has been shown already, that the sensation communicated by the eye from any visible object, has not the least resemblance to that object; and that in looking at a tree or any thing else, a full-grown man pays not the least attention to the appearance which the tree really makes to his eye; nay, that he is not even conscious of that appearance farther than as it consists in colour. It is by the sense of touch only that we acquire ideas of figure, even of plain figure; and we imagine that we perceive them by the eye only because different figures, as distinguishable by touch, are so closely associated with their corresponding visible sensations, that long before we are capable of inquiry, these two things are inseparable in the imagination. It is otherwise with children, who, when they first begin to distinguish objects by the sense of sight, appear to do it, with great deliberation, as if they first felt the proper sensation of light and colour so or so modified, and afterwards acquired, by something like a mental inference, a notion of the figure at which they are looking.

Association of Ideas. a building and a substance and its attributes and adjuncts. It is association which is the original source of all the general or complex conceptions which we have, and which even gives meaning to the words of every language. Between sounds considered in themselves, and things, or the ideas of things, every one knows that there is no natural connection; yet the idea of every known object is in the mind of every man so strictly associated with the name that it bears in its native tongue, that the presence of the one always suggests the other. It cannot indeed be otherwise, if we attend to the manner in which a child learns to affix a meaning to the words which he hears.—A child knows his mother and nurse, and indeed almost every visible object in the family, long before he acquires the power of articulation. The impressions made by these objects, and repeated daily and hourly on his brain, every one of which excites a sensation, must soon become so deep as not to be easily effaced. Numbers of them too are associated together, so that the presence of one introduces the other. It has been already observed, that ideas of sight are the most vivid and the most lasting; but the child hearing the same sound often repeated, even that sound comes in time to leave in his memory a permanent idea. He then hears the sound *nurse*, for instance, uttered at the time when he is looking earnestly at the person of the nurse, with whom he is well acquainted, and to whom he is strongly attached; and having the two ideas repeatedly excited together, they soon become so associated, that the one necessarily excites the other: the *word nurse* calls into view the *idea* of the *woman* treasured up in his imagination.

But we need not have recourse to children for the proof of our assertion. It is obvious that the name of every simple and uncompounded idea can be significant only by association. Of a complex conception the name may be made intelligible by a definition; but simple ideas cannot be defined, and between ideas and sounds there is no natural connexion, so as that the one previous to association should suggest the other. Even of complex conceptions and mixed modes, the meaning of the names is generally acquired by association; for though it is certainly true, that all such names are capable of definition, they are yet used with sufficient propriety by thousands who know not what a definition is. Were a plain unlettered man asked to define virtue, it is not probable that he could do it so as to make himself understood; yet having ideas of the *practice of justice*, *charity*, *fortitude*, &c. strictly associated in his mind with the *word virtue*, he may know the general meaning of that word as well as the most acute grammarian or the most profound philosopher.

An *alms* is a donation to a poor man; but a child who never heard of this definition knows perfectly what an *alms* is, from having often seen his parents give money to a beggar, and call what they were doing by the name *alms*. The sound of the word, after having seen the first alms given, will excite in his mind an idea of the *individual* object who received it, and of the *action* of him by whom it was given; but after having seen several poor men relieved, he comes to associate with the word *alms* any thing given to any person who needs it or appears to be in want.

So completely does this association take place between ideas or clusters of ideas, and the words by which they are expressed, that even men of letters hear and understand perfectly many words without reviewing in their minds all the ideas and relations of which they are the signs. It has been already observed, that in talking of *government*, *church*, *negotiation*, *conquest*, we seldom spread out in our minds all the simple ideas of which the compound notions signified by these terms are composed; and we now add, that the terms may be used with sufficient propriety, and be perfectly understood by those who never attempted to analyze the notions of which they are significant into their primary and constituent parts. Every man has read numberless details of the transactions of one court with another: he has heard such transactions universally called by the term *negotiation*. The term and the transactions signified by it are so closely associated in his mind, that they are in a manner inseparable: and by this association he knows the meaning of the term better than he could have done by the most complete definition; which, perhaps, he would find it difficult to give, or even to comprehend.

97 And is the source of our first notions of virtue.

We have said, that the *meaning* of the word *virtue* is acquired by association, by having often heard that sound applied to certain *actions*; but it is extremely probable, that the very *notion* of virtue, simple and uncompounded as it appears to be, is acquired in the very same manner. The *first* rudiments of the notions of *right* and *wrong* and *obligation* seem to be acquired by a child when he finds himself checked and controuled by superior power. At first he feels nothing but mere *force*, and consequently has no notion of any kind of restraint but that of necessity. He finds he cannot have his will, and therefore he submits. Afterwards he attends to many circumstances which distinguish the commands of a *father*, or of a *master*, from those of any other person. Notions of *reverence*, *love*, *esteem*, and *dependence*, are connected with the idea of him who gives those commands; and by degrees the child experiences the peculiar *advantages* of filial subjection. He sees also that all his companions, who are noticed and admired by others, obey their parents; and that those who are of a refractory disposition are universally disliked. These and other circumstances now begin to alter and modify the notion of mere necessity, till by degrees he considers the commands of a parent as something that *must not* be resisted or disputed, even though he has a power of doing it; and all these ideas coalescing, form the notions of *moral right* and *moral obligation*, which are easily transferred from the commands of a parent to those of a magistrate, of God, and of conscience. This opinion of the gradual formation of the ideas of moral right and wrong, from a great variety of elements associated together, perfectly accounts for that prodigious diversity in the sentiments of mankind respecting the objects of moral obligation; nor do we see that any other hypothesis can account for the facts. If the notion of moral obligation were a simple uncompounded idea, arising from the view of certain actions or sentiments; or were it acquired, as it certainly might be, by a chain of reasoning from the nature of God and the nature of man; why should it not in the one case be as invariable as the perception of colours or sounds, and in the other

other as our judgments of mathematical or physical truths? But though the shape and colour of a flower appear the same to every human eye; though every man of common understanding knows, that if a billiard ball be struck by another, it will move from its place with a velocity proportioned to the force of the impulse; and though all mankind who have but dipt into mathematics, perceive that any two sides of a triangle must be greater than the third side; yet one man practises as a moral duty what another looks upon with abhorrence, and reflects on with remorse. Now a thing that varies with education and instruction, as moral sentiments are known to do, certainly has the appearance of being generated by a series of different impressions and associations in some such manner as we have endeavoured to describe. Let not any man imagine that this account of the origin of moral sentiments endangers the cause of virtue, for whether those sentiments be instinctive or acquired, their operation is the very same, and in either case their rectitude must often be tried by the test of reason, so that the interests of virtue are equally safe on this as on any other scheme. See *Moral Philosophy*.

This principle of association has so great an influence over all our actions, passions, reasonings, and judgments, that there is not perhaps any one thing which deserves more to be looked after in the education of youth. Some of our ideas—such as those of a substance and its attributes, a genus and the species contained under it, a species and its several individuals, have a real connexion with each other in nature. These it is the office of our reason to trace out and to hold together in that union and order in which nature presents them to the view of the mind; for such associations constitute perhaps the greatest part of necessary and of useful truths. But there are others formed by custom and caprice, which are too often the sources of error, superstition, vice, and misery—of errors the more dangerous, and of vice the more deplorable; that if the associations have been long formed without an attempt to dissolve them, they generally become at last too strong to be broken by the most vigorous effort of the best-disposed mind. Thus, let a foolish maid * amuse or rather frighten children with stories of ghosts appearing in the dark, let her repeat these fictions till they have made a deep impression on the young minds, and the notion of ghosts will in time become so closely associated with the idea of darkness, that the one shall always introduce the other; and it may not be in the power of the children, after they have become men, and are convinced in their judgments of the falsehood and absurdity of the tales which originally frightened them, to separate entirely the notion of ghosts from the idea of darkness, or with perfect ease to remain alone in a dark room. Again, Let the idea of *infallibility* be annexed to any person or society, and let these two inseparably united constantly possess the mind; and then one body in ten thousand places at once shall, unexamined, be swallowed for an incontrovertible fact, whenever that infallible person or society dictates or demands assent without inquiry.

Some such wrong and unnatural combinations of ideas will be found to establish the irreconcilable opposition that we find between different sects in philosophy and religion; for we cannot imagine every individual of any sect to impose wilfully on himself, and knowingly to reject truth offered by plain reason. That which leads men of sincerity and good sense blindfold, will be found, when inquired into, to be some early and wrong association. Ideas independent and of no alliance to one another, are by education, custom, and the constant din of their party, so linked together in their minds, that they can no more be separated from each other than if they were but one idea: and they operate upon the judgment as if they really were but one. This gives sense to jargon, the force of demonstration to absurdities, and consistency to nonsense: it is the foundation of the greatest and most dangerous errors in the world; for as far as it obtains, it hinders men from seeing and examining.

Association of Ideas.

Before we dismiss the subject of association, it may be proper to inquire, how far it is agreeable to the account which we have given of the manner in which external objects are perceived by means of the senses, and the ideas of such objects retained in the memory.—It has been proved, we think, by arguments unanswerable, that by the organs of sense nothing is conveyed immediately to the mind but sensations which can have no resemblance to external objects, and that the perception of an object may be resolved into a process of reasoning from effects to causes.—But children, it will be said, do not reason from effects to causes, and yet they soon acquire the faculty of perceiving and distinguishing the objects with which they are surrounded. This is an undoubted truth; and it can be accounted for only by the principle of association. A child has as much the use of his senses as a full-grown man. By his eye he has the sensation of colour; by his nose, that of smell; by his ear he has the sensation of sound; and by his hand he feels heat and cold, resistance and bounded resistance. Every object which is presented to him, impresses his mind with various sensations: and these sensations combined together are probably all that he perceives for some years; for there is no reason to imagine that a boy of one or two years old has the slightest notion of what we mean by solidity, hardness, softness, or indeed of that which is termed *substance*. Yet when two or more objects are present, he may easily distinguish the one from the other, because the sensations excited by the one must differ from those excited by the other, as much as the real qualities of the one are different from the real qualities of the other; and by distinguishing between his own sensations, he in effect distinguishes between the objects which produce these sensations. His sensations too being frequently excited, leave behind them ideas in his memory or imagination; and those ideas, from having been imprinted together and never separated, become in time so closely associated, that whenever one of them is called into view, the others necessarily make their appearance with it. Thus a child has a set of combined sensations excited in his mind by the presence of his nurse; he has a different cluster excited, suppose by the presence of his mother. These are often repeated and leave deep traces behind them; so that when the mother or the nurse makes her appearance, she is immediately recognised as a known object; or, to speak more correctly, the child feels the very same sensations

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The principle of association operates in our perception of external objects;

tions which he has felt before, from which he has experienced pleasure, and of which he has the ideas treasured up in his memory or imagination. A stranger, on the other hand, must affect him with a set of new sensations, and of course will be distinguished from a known object as accurately as if the child were possessed of the notions of solidity, substance, qualities, and distance. A man born blind, who knew not that such things as fire and snow had never existed, would yet distinguish the one from the other the moment that he should be brought within their influence. He could not indeed apply their names properly, nor say which is the fire and which is the snow, nor would he at first have any notion of either of them as a real, external and distant object; but he would certainly distinguish his own sensations, the sensation of heat from that of cold. It is just so with a child: At first he perceives nothing but different sensations. These he can distinguish; and as they are caused by different objects, in distinguishing between the sensations he will appear to distinguish between the objects themselves. In a short time, however, he acquires, by the following process, some inaccurate notions of distance He looks, for instance, earnestly in his nurse's face, and at the same time touches her cheek perhaps by accident. He repeats this operation frequently, till the sensation communicated by his eye comes to be associated with that of his touch, and with the extending of his arm; and being all treasured up as associated ideas in the memory, the sight of his nurse makes him ever afterwards stretch out his hands with a desire to touch her. All this while there is not the slightest probability that the child has any notion of *substance*, or *qualities*, or of any thing beyond his own *sensations*, and the means by which he has experienced, that sensations which are pleasant may be obtained, and that such as are painful may be avoided. The precise time at which a child begins to think of external things we cannot pretend to ascertain; but we are persuaded that it is later than many persons imagine, and certainly not till he has made considerable progress in the exercise of reason. Prior to that period the things which men know to be bodies, are known to children only as sensations and ideas strongly bound together by the tie of association.

99 and seems to distinguish memory from imagination;

But if association be of such importance in the act of sensation, it is of still greater in that of retention; for it seems to constitute the whole difference that there is between imagination and memory. By many of the ancient, as well as by some modern philosophers, these two faculties seem to have been confounded with each other; but between them there is certainly a great difference, though they likewise resemble each other in some respects. An idea of memory, considered by itself, makes the very same appearance to the intellect as an idea of imagination. We contemplate both as if they were equal, though faint and distant perceptions: but the one is attended with the conviction, that it is the idea of an object which has really been perceived at some period of past time; whilst the other is attended with no conviction, except that the idea itself is actually present to the mind. Mr Hume has said, that ideas of memory differ from those of imagination only in being more vivid and distinct; but certainly this is not always the case. An idea of imagination has sometimes been taken for a real perception, which an idea of memory can never be. The difference between these two kinds of ideas, we are persuaded, arises chiefly, if not wholly, from association. Every idea of memory is associated with many others, and those again with others down to the very moment of the energy of remembrance; whereas ideas of imagination are either the voluntary creatures of the fancy at the moment of their appearance, in which case we should call them conceptions; or they are ideas which we have actually received from sensation, but which, on account of some link being broken in the vast chain of association, we cannot refer to any real objects. What gives probability to this conjecture is, that ideas often appear in the mind which we know not whether to refer to the memory or imagination, nothing being more common than to hear a person say, I have in my head the idea of such or such an object; but whether I remember or only imagine the object, I am very uncertain. Afterwards, however, by turning the idea over and over in the mind, he finds other ideas make their appearance, till at last clusters of them come into view, and associate so closely with the principal idea, which was the object of doubt, as to convince the judgment that it is an idea of memory.

100 and to b the grou of our be lief of w we reme ber.

It has been asked, Why we believe what we distinctly remember? and to that question it has been supposed that no answer can be given. But it appears to us, that association is the ground of belief in this as it will be found to be in other instances; and that a man believes he washed his hands and face in the morning, because the idea of that operation is so strongly linked in his mind to the whole train of ideas which have arisen in it through the day, that he cannot separate the first from the last, that which was a sensation in the morning from the sensations which are present at the instant of remembrance. As these ideas are associated by nature, each must pass in review in its proper order; so that in so short a space of time there is no danger, and hardly a possibility, of taking the first for the last, or the last for the first. Nay more, we will venture to hazard an opinion, that every past event of a man's life, which he distinctly remembers, is tied by the chain of association to his present perceptions. That this is possible is certain, since it is not difficult to conceive how it may be done. The principal events of a single day may surely be so linked together as to be all distinctly reviewed in a cluster of ideas on the morrow. Of these events some one or other must be the most important, which will therefore make its appearance as an idea more frequently than the rest, and be more closely associated with the events of next day. Some event of that day will, for the same reason, be more closely associated with it than the others; and these two, dropping perhaps all the rest of their original companions, will pass on together to the third day, and so on through weeks, and months, and years. In the compass of a year, several things must occur to make deep impressions on the mind. These will at first be associated together by events of little importance, like the occurrences of a single day. Whilst these feeble chains, however, continue unbroken, they will be sufficient to link the one

Association of ideas. one important event to the other, and to bring them both into view at the same time, till at last these two, from appearing so often together, will in time unite of themselves, and the intermediate ideas be completely effaced. Thus may two or three important events of one year be associated with such a number of similar events of another year, so that the ideas of the one shall always introduce to the mind the ideas of the other; and this chain of association may pass from the earliest event which we distinctly remember through all the intermediate years of our lives down to the instant when memory is exerted.

To this account of memory it may perhaps be objected, that it gives us no distinct notion of time. Every thing that is remembered is necessarily believed to have been present in some portion of past time; but association brings into view nothing but a series of events. This objection will be seen to have no weight when we have inquired into the nature of time, and ascertained what kind of a thing it is. It will then perhaps appear, that duration itself, as apprehended by us, is not distinguishable from a series of events; and that if there were no train of thought passing through our minds, nor any motion among the objects around us, time could have no existence. Meanwhile, whatever become of this opinion, we beg leave to observe, that our theory of remembrance is perfectly consistent with the commonly received notions respecting time; and indeed, that it is the only theory which can account for numberless phenomena respecting past duration. It is universally allowed, that if motion, or a succession of events, do not constitute time, it is the only thing by which time can be measured. Now it is a fact which no man will deny, that the distance of time from the present *now* or instant to the earliest period which he distinctly remembers, appears to his view extremely short, much shorter than it is said to be in reality; and that one year, when he looks forward, appears longer than two, perhaps longer than ten, when he looks backward. Upon our principles this fact is easily accounted for. We remember nothing which is not linked by a chain of associations with the perceptions of the present moment; and as none but a few of the most important events of our lives can be linked together in this manner, it hence follows, that events which, in the order of succession, were far *distant* from each other, must thus be brought *together* in the memory, and the whole chain be contracted within very short limits. But when we figure to ourselves a series of future events, we employ the active power of fancy instead of the passive capacity of retention; and can therefore bring within the compass of one periodical revolution of the sun a longer series of imaginary events succeeding each other, than is preserved of real events in our memory from the earliest period of our existence: So perfectly does our theory accord with this well known fact. On the other hand, if memory be an original faculty of the mind totally independent of association, and of which no other account is to be given than that it necessarily commands our belief, why is it a faculty which, with regard to duration, thus uniformly deceives us? and how comes it to pass, that to a man whose memory is tenacious, who has read much, seen many countries, and been engaged in various occurrences, any determinate portion of past time always appears longer than to another man whose memory is feeble, and whose life has been wasted in ease and idleness? To these questions we know not what answer can be given upon any other principle than that which makes the evidence of memory depend upon association. But if we remember nothing but what is linked to the perception or idea which is present with us at the time of remembrance, and if duration is measured by the succession of events, it is obvious that any portion of past time must necessarily appear longer to him who has many ideas associated in the mind than to him who has but few.

Of Consciousness and Reflection.

101

The importance of association in the philosophy of the human mind.

There is not perhaps a single fact of greater importance in the philosophy of the human mind than the *association of ideas;* which, when thoroughly understood, accounts for many of those phenomena which some late writers of name have, with injury to science and with danger to morality, attributed to a number of distinct and independent instincts. It is for this reason that we have considered it so minutely, and dwelt upon it so long; and in addition to what we have said on the subject, we beg leave to recommend to our more philosophical readers the diligent study of Hartley's Observations on Man (R). In that work we think several things are taken for granted which require proof; and some which, we are persuaded, have no foundation in nature: but, with all its defects, it has more merit than any other treatise on the sensitive part of human nature with which we are acquainted.

Chap. VI. *Of* Consciousness *and* Reflection.

102

Consciousness, what it is, and what are its objects.

Sensation, remembrance, simple apprehension, and conception, with every other actual energy or passion of the mind, is accompanied with an inward feeling or perception of that energy or passion; and that feeling or perception is termed *consciousness. Consciousness* is the perception of what passes in a man's own mind at the *instant* of its passing there; nor can we *see, hear, taste, smell, remember, apprehend, conceive*, employ our faculties in any manner, enjoy any pleasure, or suffer any pain, without being *conscious* of what we are doing, enjoying, or suffering. *Consciousness* is only of things *present* *; and to apply it to things *past*, is to confound *consciousness* with memory or *reflection*. One cannot say that he is conscious of what he has seen or heard and now remembers: he is only conscious of the act of remembrance; which, though it respects a past event, is itself a present energy. It is likewise to be observed, that consciousness is only of things in the mind or conscious being, and not of things external. It is improper in any person to say that he is *conscious* of

* *Reid's Essays on the Intellectual Powers of Man.*

(R) Since this was written, Mr Stewart's *Elements of the Philosophy of the Human Mind* have been published; in which the reader will find many excellent remarks on the nature and influence of the associating principle.

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of the table before him; he perceives it, he *sees* it, and he may with great propriety say, that he is *conscious* he perceives or sees it; but he cannot say that he is conscious of the table itself, for it is only his immediate energy of perception that can be the object of consciousness. All the operations of our minds are attended with consciousness; which is the only evidence that we have or can have of their existence. Should a man take it into his head to think or to say that his consciousness may deceive him, and to require a proof that it cannot, we know of no proof that can be given him: he must be left to himself as a man that denies first principles, without which there can be no reasoning. Every attempt to prove this point, or to set it in a clearer light, would only serve to render it more dark and unintelligible. I *think*, I *feel*, I *exist*, are first truths, and the basis of all human knowledge.

103 Des Cartes' argument from consciousness for his own existence.

This has given rise to the question, whether Des Cartes did not fall into an absurdity when, inferring his own existence from his actual thought, he said, *Cogito, ergo sum.* This argument has been called a pitiful sophism, and a *petitio principii;* because, before a man take it for granted that he thinks, he must also, it is said, take it for granted that he exists, since there cannot be thought where there is no existence. Now it must be confessed, that if Des Cartes pretended by this argument to give us a fresh conviction of our own existence, his endeavours were useless and puerile; because a man capable of being convinced by the arguments of another, must have a previous conviction of his own existence: but the argument itself is certainly neither a sophism nor a *petitio principii.* Those * who defend Des Cartes assert, and there is no reason to doubt the truth of their assertion, that his only view in urging such an argument was not to prove the truth of our existence, but to exhibit the order of that process by which we arrive at the knowledge of the fact; and this he has very clearly done by analyzing the truth into its first principles. A stone exists as well as the human mind; but has the stone any knowledge of its own existence? No man will say that it has; neither should we have any knowledge of ours, did we think as little as the stone. We certainly *might* exist without thinking, as it is probable we do in very sound sleep; and in that state our existence might be known to other beings, but it could not possibly be known to ourselves: for the only things of which the mind is conscious, or has immediate knowledge, are its own operations. I *exist* is therefore a legitimate inference from the proposition I *think;* and the observation that it is so may be useful to show us the procedure of the mind in the acquisition of knowledge; but it has little merit as an argument, and still less as a discovery, though, being strictly true and just, it should never have been exposed to ridicule.

* See *Buffier's First Truth.*

104 Reflection, what it is, and how different from consciousness.

It is to be observed, that we are conscious of many things to which we give very little attention. We can hardly attend to several things at the same time; and our attention is commonly employed about that which is the *object* of our thought, and rarely about the thought itself. It is in our power, however, when we come to the years of understanding, to give attention to our own thoughts and passions, and the various operations of our minds. And when we make these the objects of our attention, either while they are present, or when they are recent and fresh in our memory, we perform an act of the mind which is properly called *reflection.* This *reflection* ought to be distinguished from *consciousness* *; with which it is confounded sometimes by Locke, and often by the learned author of Ancient Metaphysics. All men are *conscious* of the operations of their own minds at all times while they are awake, nor does it appear that brutes can be wholly destitute of consciousness; but there are few men who *reflect* upon the operations of their minds, or make them the objects of thought; and it is not probable that any species of brutes do so.

* *Reid's Essays on the Intellectual Powers of Man.*

From infancy, till we come to the years of understanding, we are employed solely about sensible objects. And although the mind is conscious of its operations, it does not attend to them; its attention is turned solely to the objects about which these operations are employed. Thus, when a man is angry, he is *conscious* of his passion; but his *attention* is turned to the *person* who offended him and the *circumstances* of the *offence*, while the *passion of anger* is not in the least the object of his attention. The difference between *consciousness* and *reflection*, is like the difference between a superficial view of an object which presents itself to the eye, while we are engaged about something else, and that attentive examination which we give to an object when we are wholly employed in surveying it. It is by consciousness that we immediately acquire all the knowledge which we have of mental operations; but attentive reflection is necessary to make that knowledge accurate and distinct. *Attention* is a voluntary act; it requires some exertion to begin and continue it; and by great exertion it may be continued for a considerable time; but *consciousness* is involuntary, and of no continuance, changing with every thought. The power of reflection upon the operations of their own minds does not at all appear in children. Men must have come to some ripeness of understanding before they are capable of it. Of all the powers of the human mind it seems to be the last that unfolds itself. Most men seem incapable of acquiring it in any considerable degree; and many circumstances conspire to make it to all men an exercise of difficulty. The difficulty, however, must be conquered, or no progress can be made in the science of our own or of other minds.

105 All our notions of mental energies got by reflection.

All the notions which we have of mind and of its operations are got by reflection; and these notions are by Mr Locke called *ideas of reflection.* This term we think extremely ill chosen; and we believe it has been the source of much error and confusion among Locke's followers. A man, by attending to the operations of his own mind, may have as distinct *notions* of remembrance, of judgment, of will, of desire, as of any object whatever: but if the secondary perception of a sensible object, that appearance which it has to the mind when viewed in the memory or imagination, be properly called an *idea*, it is certain that of the operations of the mind itself there can be no ideas; for these operations, when reflected on, make no appearance without their objects either in the memory or in the imagination. Nothing is more evident, in fact, than that we have no *ideas*, in the original and proper meaning of the word, but of sensible objects upon which the mind exerts its first operations. Of these operations we have indeed a consciousness;

Consci- ... ces and ... ection.

consciousness; but abstracted from their objects we cannot frame of them any idea or resemblance. We are *conscious* to ourselves of *thinking*, *willing*, *remembering*, *discerning*, *reasoning*, *judging*, &c. but let any one look into himself, and try whether he can there find any *idea* of *thinking*, or *willing*, &c. entirely separate and abstracted from the *object* of thought or will. Every man who has seen a tree or a house, will find in his mind ideas of these objects, which he can contemplate by themselves, independent of every thing else; but no man can contemplate the *idea* of thinking or desiring without taking into view the thing thought on or desired. It is plain, therefore, that the energies of *thinking*, *willing*, and *desiring*, with all their various modifications, are not themselves *ideas*, or capable of *communicating* ideas to be apprehended, as the ideas of bodies are apprehended by the pure intellect. They are the *actions* and *workings* of the *intellect itself* upon ideas which we receive from the objects of sense, and which are treasured up in the memory or imagination for the very purpose of furnishing the intellect with materials to work upon. Between *ideas* and the *energies of thinking* there is as great and as obvious a difference as there is between a *stone* and the *energies* of him by whom it is cast. Ideas are the passive subjects; the energies of thinking are the operations of the agents. Ideas are relicts of sensation, and have a necessary relation to things external; the energies of thinking are relicts of nothing, and they are wholly and originally internal.

106 ... know- ... e of the ... rations ... ntellect ... ediate, ... not by ... inter- ... tion of ... s.

That we can in no sense of the word be said to have *ideas* of the operation of the intellect, will be still more evident, if we consider by what means we acquire the knowledge which we have of those operations. It has been already observed, that when our thoughts are employed upon any subject, though we are conscious of thinking, yet our *attention* is commonly employed upon the *object* of our thought, and not upon the *thought* itself; and that if we would give attention to our thoughts and passions, we must do it by a reflex act of the mind, whilst the act of thinking is still recent and fresh in our memory. Thus, if a man wishes to know what perception is, it is not the time to make the inquiry while he is looking at some rare or beautiful object; for though he is *conscious* of the energy of perceiving, the *object* of perception employs all his *attention*. But the time to make this inquiry is either when the object has become familiar to him, or presently after it is removed from his sight. In the former case, he can look upon it without emotion, pay attention to every step in the process of perception, and be immediately conscious what perception is. In the latter case, by turning his attention inwards, and reflecting on what he did or felt when the object was before him, he will find clear and vivid ideas of every thing which he perceived by his sense of sight; but he will find no *idea* of the act of *seeing* or *perceiving*. On the contrary, if he be capable of sufficient attention, he will observe that his intellect is employed in the very same manner upon the *ideas* that it was upon the original *sensations*; and of that employment, and the manner of it, he will be equally conscious as he was of the original energy exerted in sensation. There is indeed this difference between the two, without which reflection could make no discoveries, that the most vivid ideas being still faint when compared with actual sensations, the intellect is not so wholly engrossed by them, as it was by the original objects, nor is it so rapidly carried from idea to idea as it was from sensation to sensation. It is thus at leisure to attend to its own operations, and to know what they are; though to form *ideas* of them as separate from their objects, is absolutely impossible. Every man capable of paying attention to what passes within himself when he sees, hears, and feels, &c. may have very accurate *notions* of *seeing*, *hearing*, and *feeling*, &c. but he cannot have *ideas* of them as he has of the *objects* of *sight*, *hearing*, and *touch*.

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The same is the case with respect to the exertion of our reasoning faculties. A man must have distinct and clear *ideas* to reason upon, but he can have no *idea* of reasoning itself, though he must be conscious of it, and by attention may know what it is. When a man sits down to study for the *first time* a proposition in the Elements of Euclid, he certainly employs his reasoning faculty, and is conscious that he is doing so; but his attention is wholly turned to the diagram before him, and to the several ideas which the diagram suggests. Afterwards, when he has mastered the proposition, he may go over it again, with a view to discover what reasoning is; but he will not find he has any *idea* of reasoning as he has of the diagram. He will only exert that faculty a second time, and perceive one truth linked to and depending upon another in such a manner that the whole taken together forms a complete demonstration. In a word, the operations of our own minds, when attention is paid to them, are known immediately by consciousness; and it is as impossible that we should have ideas of them, as that a living man should be a picture upon canvas. He who attends to what passes in his own mind when he perceives, remembers, reasons, or wills, must know by consciousness what these operations are, and be capable of forming very accurate notions of them, as connected with their objects; and he who does not attend to what passes in his own mind will never acquire any notions of them, though he were to read all that has been written on the subject from the days of Pythagoras to those of Dr Reid.

107 There are things which we know partly by sensation and partly by reflection, &c.

As we acquire ideas of external objects by means of our senses; and notions of perceiving, remembering, reasoning, and willing, &c. by reflecting on the operations of our own minds; so there are other things of which we acquire notions, partly by sensation, partly by reflection, and partly by means of that faculty of which it is the more peculiar office to compare ideas and to perceive truth. Such are *substance*, *body*, *mind*, with their several qualities, adjuncts, and relations; the knowledge of which, as has been already observed, constitutes what in strictness of speech is termed the science of *metaphysics*. These shall be considered in order, after we have investigated the nature of truth, and inquired into the several sources of evidence; but there is one notion, about the origin and reality of which there have been so many disputes, which in itself is of so great importance, and which will be so intimately connected with all our subsequent inquiries, that it may not be improper to consider it here.—The notion to which we allude is of POWER.

108 Our notion of power how acquired.

Among the objects around us we perceive frequent changes, and one event regularly succeeding another.

 Gold

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Gold thrown into the fire is changed from a solid to a fluid body. Water exposed to a certain degree of cold is changed from a fluid to a solid body. Night succeeds to day, and summer succeeds to winter. We are conscious of new sensations in ourselves every hour. We are likewise conscious of reasoning, willing, and desiring; and we know that by an exertion of will we can rise or sit, stand still or walk, call one idea into view, and dismiss others from our contemplation. Experience teaches us, that it is not occasionally, but always, that gold is changed into a fluid, by being thrown into the fire, and water into a solid body by being exposed to a certain degree of cold; that night succeeds to day, and summer to winter. These changes have regularly taken place since the creation of the world; and it has never once been observed that water was made solid by fire, or gold rendered liquid by cold. Were we not assured by experience that our own voluntary motions are produced by exertions of our minds, of which we are conscious, and that without such exertions those motions would never have taken place, we should probably have considered the liquefaction of gold as an event equally independent of fire, though uniformly conjoined with it, as night is independent of day, and day of night. But having experienced that we can move or not move our bodies as we please; that when it is our will to sit, we never get up to walk; and that when we wish to walk, we always do it except prevented by external violence: having likewise experienced, that by a thought, by some internal and inexplicable exertion of our minds, we can call up in our memory or imagination one idea and dismiss others from our mental view; we are led to believe with the fullest conviction, that all those motions of our bodies which in common language are termed *voluntary*, and that succession of ideas which follows a conscious exertion of the mind, depend upon ourselves. In other words, we are necessitated to believe that we have a *power* to move or not move our bodies in many cases, and a *power* to turn our attention to one idea in preference to others.

It is thus that we acquire the notion of *power* in ourselves, which we easily transfer to other objects. Knowing that the various motions of our bodies thus effected proceed from power, we are naturally led to inquire whether the changes which we perceive in other bodies may not proceed from *power* likewise, i. e. from something analogous to that power, of the exertions of which we are conscious in ourselves. Now uniform experience teaching us that gold is liquefied by being thrown into the fire, and that water is made solid by being exposed to cold; we infer with the utmost certainty that there are *powers* in fire and cold to produce these changes, and that without the exertion of such *powers* these changes would not be produced. We cannot indeed say of external powers, as we can of our own, in what substance they inhere. We know with the utmost certainty that the voluntary motions of our hands, &c. are produced by a power not inherent in the hands but in the mind, for of the exertion of that power we are conscious; but we do not know whether the power which liquefies gold be inherent in that sensible object which we call *fire*, or in something else to which fire is only an instrument. We learn by observation, that the minute particles of fire or heat insinuate themselves between the particles of gold, and, if we may use the expression, tear them asunder; but whether they do this in consequence of a *power* inherent in themselves, or only as instruments impelled by another *power*, is a question which *observation* cannot enable us to answer.

Were we not conscious of the exertion of our own powers, it seems not conceivable that we could ever have acquired any notion of power at all; for power is not an object of sense, nor, independent of its operations, is it indeed an object of consciousness. In external operations, all that we perceive is *one thing*, in which we suppose the *power* to reside, followed by another, which is either the *change* or that on which the change is *produced*; but the exertion of the power itself we do not perceive. Thus we perceive gold, after it has been some time in the fire, converted from a solid to a fluid body; but we perceive not by our senses either the power or the energy of the power which operates to this conversion. In the exercise of our own powers, the case is otherwise. When a man puts his hand to his head, and afterwards thrusts it into his bosom, he not only perceives by his senses the change of position, but is also conscious of the energy or exertion by which the change was produced.

"Suppose (says Mr Hume *) a person, though endowed with the strongest faculties of reason and reflection, to be brought on a sudden into this world; he would indeed immediately observe a continual succession of objects, and one event following another, but he would not be able to discover any thing farther. He would not at first by any reasoning be able to reach the idea of cause and effect; since the particular powers by which all natural operations are performed never appear to the senses. The impulse of one billiard ball is attended with motion in the second. This is the whole that appears to the *outward* senses. The mind feels no sentiment or *inward* impression from this succession of objects; consequently there is not, in any single particular instance of cause and effect, any thing which can suggest the idea of power or necessary connexion. From the first appearance of an object, we never can conjecture what effect will result from it; but, were the power or energy of any cause discoverable by the mind, we could foresee the effect even without experience; and might at first pronounce with certainty concerning it by the mere dint of thought and reasoning. It is impossible, therefore, that the idea of power can be derived from the contemplation of bodies in single instances of their operations; because no bodies ever discover any power which can be the original of this idea."

* Essa

There is a sense in which this reasoning is unquestionably just. A man who had never been conscious of exerting power in himself, would certainly not acquire the notion of power from observing a continual succession of external objects. The impulse of one billiard ball being followed by the motion of another, would no more lead him to the notion of power in the former, than the succession of night to day would lead him to the notion of a power in light to produce darkness. When Mr Hume says, "that from the *first* appearance of an object *we* can never conjecture what effect

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fect will result from it," he uses language that is ambiguous, and utters an assertion which is either true or false according to the sense in which it is understood. If it be meant, that after having reflected on the operations of our own minds, and learned by experience that motion is communicated by impulse from one ball of ivory to another, we could not conjecture whether a similar effect would be produced by the impulse of balls made of other hard bodies which we had never before seen, the assertion is manifestly false. A man who had but once seen motion communicated in this manner from one *ivory* ball to another, would certainly conjecture that it might be communicated from one *wooden* ball to another; and if he had seen it repeatedly communicated from one ball to another of different substances, he would infer, with the utmost confidence, that it might be communicated from ball to ball of whatever substance composed, provided that substance be hard, or of a similar texture with the balls to the impulse of which he had formerly paid attention. If by this ambiguous phrase the author only means, as is probably the case, that from the first appearance of an object to which we had never before observed any thing in any respect similar, we could not conjecture what effect would result from it; or if his meaning be, that a man suddenly brought into the world, who had never acquired such a notion of power as may be had from attention to the energies and operations of our own minds, would not, by observing an effect to result from one body, conjecture from the first appearance of another similar body what effect would result from it; in either of these cases his assertion is certainly true, and tends to prove, that without the consciousness of the operations of our own minds we could never acquire a notion of power from the changes perceived by our senses in external objects.

109 Hume attempts to prove that we have no notion whatever of power.

But Mr Hume, not contented with denying, which he might justly do, that we could ever have derived the idea of power merely from observing the continual succession of external objects, labours hard to prove that we have no notion of power at all, and that when we use the word *power*, we do nothing more than utter an insignificant sound. To pave the way for the arguments by which so extravagant a paradox is to be supported, he lays it down as a "proposition which will not admit of much dispute, that all our ideas are nothing but copies of our impressions; or, in other words, that it is impossible for us to *think* of any thing that we have not antecedently *felt* either by our external or internal senses." As this proposition, however, will admit, it seems, of *some* dispute, he takes care, before he applies it to the purpose of demolishing all power, to support it by two arguments. "First (says he), when we analyze our thoughts or ideas, however compounded or sublime, we always find that they resolve themselves into such simple ideas as were copied from a precedent feeling or sentiment. Those who would assert, that this position is not universally true nor without exception, have only one, and that an easy, method of refuting it; by producing that idea, which, in their opinion, is not derived from this source. Secondly, If it happen, from a defect of the organ, that a man is not susceptible of any species of sensation, we always find that he is as little susceptible of the correspondent ideas. A blind man can form no notion of colours, a deaf man of sounds. And though there are few or no instances of a like deficiency in the mind, where a person has never felt, or is wholly incapable of a sentiment or passion that belongs to his species: yet we find the same observation to take place in a less degree. A man of mild manners can form no idea of inveterate revenge or cruelty; nor can a selfish heart easily conceive the heights of friendship and generosity."

110 His reasoning sophistical.

As these propositions are the engines by which all power is banished from the world, it may not be improper, before we proceed to inquire by what means they perform so arduous a task, to consider their own inherent strength; for if they be weak in themselves, their work, however dexterously they may be employed, can have no stability. We have already noticed the perverseness of this writer's language, when it confounds *sensations* with *impressions*; but here it is still more perverse, for passions, sentiments, and even *consciousness*, are styled *impressions*. When sensations are confounded with impressions, the effect is only mistaken for the cause, it being universally known that sensations proceed from impressions made upon the organs of sense. When consciousness is confounded with an impression, one thing is mistaken for another, to which it is universally known to have neither resemblance nor relation. But, not to waste time upon these fallacies, which, though dangerous if admitted, are yet too palpable to impose upon a reader capable of the slightest attention, let us examine the propositions themselves. The most important, and that for the sake of which alone the others are brought forward, is, that it is impossible for us to *think* of any thing that we have not immediately *felt*, either by our external or internal senses." Did Mr Hume then never *think* of a mathematical *point*, or a mathematical *line*? Neither of these things is capable of being *felt* either by making an impression upon the organs of sense or as an object of consciousness; and therefore it is impossible that he should ever have had ideas of them such as he doubtless had of sensible objects; yet in the most proper sense of the word *think* (s), he certainly thought of both points and lines; for he appears to have made considerable progress in the science of geometry, in which he could not have proceeded a single step without a perfect knowledge of these things, on which the whole science is built. It is not therefore true, that our thoughts or ideas, when analyzed, always resolve themselves into such simple ideas as were copied from a precedent feeling or sentiment; for every mathematical figure of which we can think resolves itself into a point and motion; and a point having

(s) *Thinking*, in the propriety of the English tongue, signifies that sort of operation of the mind about its ideas wherein the mind is active; where it, with some degree of voluntary attention, considers any thing.—*Locke*.

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111 Things of which we can have no *ideas* may themselves be the objects of thought.

But ideas are not the only objects of thought. We have already given our reasons for restricting the word *idea* to that appearance which an object of sense, when reflected on, makes either in the memory or imagination. Such was undoubtedly its original signification; and had it never been used to denote other and very different objects, much error and perplexity would have been avoided, which now disgrace the science of metaphysics. Things may *themselves* be the objects of thought; and when that is the case, to think of their *ideas*, were it possible to do so, would be worse than useless; for we may certainly know a man better by looking at himself than by looking at his picture. Of things which are *themselves* the objects of thought, we have either a *direct* or a *relative* knowledge. We know directly the actual operations of our own minds by the most complete of all evidence, that of consciousness; and we have a *relative* notion of mathematical points and lines: but neither of mental energies nor of these external things (T) can we possibly have any *idea*.

112 We have only relative notions of some things,

It is well observed by Dr Reid*, that our notions both of body and mind are nothing more than relative. "What is body? It is, say philosophers, that which is extended, solid, and divisible. Says the querist, I do not ask what the properties of the body are, but what is the thing itself? let me first know directly what body is, and then consider its properties. To this demand I am afraid the querist will meet with no satisfactory answer; because our notion of body is not direct, but relative to its qualities. We know that it is something extended, solid, and divisible, and we know no more. Again, If it should be asked, what is mind? It is that which thinks. I ask not what it does, or what its properties are, but what it is? To this I can find no answer; our notion of mind being not direct, but relative to its operations, as our notion of body is relative to its qualities (U)."

* *Essay on the Active Powers of Man.*

113 about which, however, we can reason with the utmost precision

Our notion of a mathematical point is of the very same kind. What is a point? It is, says Euclid, that which has no parts and no magnitude. Replies the querist, I ask not either what it has or what it has not, let me first know what it is? To this second question, it might perhaps be answered, that a mathematical point is that which by motion generates a line. But, rejoins the querest, I am not inquiring what it generates; give me a direct idea of the point itself? or, if that cannot be done, as surely it cannot, tell me what its offspring a line is? A line, says Euclid, is length without breadth. I have no idea, replies the querist, of length without breadth. I never felt an *impression* from a sensible object which did not suggest length, breadth, and thickness, as inseparably united; and I can have no idea which is not the *copy* of a *former impression.* To assist the querist's conception, it may be said that lines are the boundaries of a superficies, and that superficies are the boundaries of a solid body; and of a solid body every man has a clear and direct idea, in the most proper sense of the word. Here then are several things, viz. points, lines, and superficies, of not one of which is it possible to form a direct notion; and yet we know them so thoroughly, from the relation which they bear to other subjects, that we can reason about them with a precision and certainty which only the mathematical sciences admit.

114 And such is power

The great advantage of these sciences above the moral, Mr Hume himself expressly admits: but he attributes it to a wrong cause, when he says it consists in this, that the "ideas of the former being *sensible* are always clear and determinate;" for we see that the notion of a point or of a line is merely relative, and cannot possibly be the copy of a sensation, or, in his language, of a sensible impression. If then we have clear and determinate notions of points and lines, and may reason about them without ambiguity, as he acknowledges we may, what is there to hinder us from having an equally clear and determinate notion of power, or from reasoning about it with as little ambiguity (V): Why, says he, we are not conscious of power. And to prove this position, which needs no proof,

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(T) By calling mathematical points and lines external things, we do not mean to attribute to them any corporeal existence. We know well that they are merely creatures of the mind, and that if there were no mind, they could have no existence. But twenty men may at the same instant have a notion of the same lines and the same points; and therefore these lines and points have an existence independent of, and external to, any *one* mind, at least to any one *human* mind. The objects, however, of which a man is conscious, are in no sense whatever external, for they are present to no human mind but his own.

(U) The opinions of philosophers concerning corporeal and spiritual substances shall be considered more fully hereafter. In quoting from Dr Reid on another subject, we have been obliged to anticipate his opinion, which will be found to be not more modest than just.

(V) "There are some things of which we can have both a direct and relative conception. I can directly conceive ten thousand men, or ten thousand pounds, because both are objects of sense, and may be seen. But whether I see such an object, or directly conceive it, my notion of it is indistinct; it is only that of a great multitude of men, or of a great heap of money; and a small addition or diminution makes no perceptible change in the notion I form in this way. But I can form a relative notion of the same number of men or of pounds by attending to the relations which this number has to other numbers greater or less. Then I perceive that the relative notion is distinct and scientific; for the addition of a single man, or a single pound, or even of

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proof, he makes many observations that, however just, might certainly have been spared. Of these one is, that "a man suddenly struck with a palsy in the leg or arm, or who had now lost these members, frequently endeavours at first to move them, and employ them in their usual offices. Here he is as much conscious of power to command such limbs, as a man in perfect health is conscious of power to actuate any member which remains in its natural state and condition. But consciousness never deceives. Consequently, neither in the one case nor in the other are we ever conscious of any power." This is true; we never are conscious of any power; but we are frequently conscious of actual energies: and the man who, after being suddenly struck with a palsy, endeavours in vain to move his leg or arm, is as conscious of energy as he who in health makes the attempt with success. Nor let it be imagined that his consciousness deceives him; for, as Mr Hume justly observes, consciousness never deceives. He is certain of the *energy*, but finds by experience that the *instrument* of this energy has suddenly become disordered and unfit for its usual office. In this and this alone consists the difference between the paralytic and the man whose limbs are sound. The one may be as conscious of energy as the other, and his consciousness may be equally infallible. What then is this energy? Mr Hume will not say that it is an *idea*, for it is not the copy of any antecedent impression; besides, he has somewhere allowed that ideas are never active. Is it then a substance? Impossible! for it is not permanent: and we believe no man will venture to affirm, or even to suppose, that the same substance can be repeatedly annihilated, and as often created. Is it then the occasional exertion of some substance? This must be the truth; for no other supposition remains to be made. If so, that substance must be possessed of *power*; for a capacity of exerting actual energy is all that is meant by the word *power*. —"Wherever there is a *capability* of energy or exertion, there must be *power*; for though there can be no exertion without power, there may be power that is not exerted *. Thus a man may have *power* to speak when he is silent; he may have power to rise and walk when he sits still. But though it be one thing to *speak* and another to have the *power* of speaking, we always conceive of the power as something which has a certain relation to the effect; and of every power we form our notion by the effect which it is able to produce. Nor is it only in speaking and moving his limbs that a man is conscious of energy. There is as much energy, though of a different kind, in *thinking* as in *acting*. Hence the powers of the human mind have been divided into active and speculative. By the former we move the body; and by the latter we see, hear, remember, distinguish, judge, reason, and perform upon our notions and ideas every other operation which is comprehended under the general word *to think*."

* Reid's Essays on the Active Powers of Man.

115 Locke's passive power an improper expression.

Mr Locke † has introduced into his theory of power another distinction than that which we have made between active and speculative powers. Observing by our senses, under which on this occasion memory is certainly included, various changes in objects, we collect, says he, a possibility in one object to be changed, and in another a possibility of making that change, and so come by that idea which we call power. Thus we say that fire has a power to melt gold, and that gold has a power to be melted. The first he calls *active*, the second *passive*, power. But to say that the *possibility* of being changed is *power*, seems to be a very improper mode of speaking, and such as may lead to consequences which the excellent author certainly held in abhorrence. It tends to make unwary readers imagine that the passive subject is as necessary to the existence of power, as the active being of which power is an attribute; but if the universe had a beginning, and if its Creator be immutable, two propositions which Mr Locke firmly believed, there certainly was power when there was no change, nor any thing existing which was capable of change. He owns, indeed, that active power is more properly called power than the other; but we see no propriety at all in passive power. "It is (in the language of Dr Reid) a powerless power, and a contradiction in terms."

† *Essay*, book ii. chap. 21.

116 Just observations of the same author respecting power as belonging to body or mind.

But though Locke here uses improper terms, he has other observations with which we have the honour fully to agree, and which lead to consequences the reverse of that impiety which seems to follow from the notion of *passive* power. He observes, that "we have from body no idea at all of thinking, nor any idea of the beginning of motion. A body at rest affords us no idea of any active power to move; and when it is set in motion itself, that motion is rather a passion than an action in it. For when the ball obeys the stroke of a billiard stick, it is not any action of the ball, but a passion: also, when by impulse it sets another ball in motion that lay in its way, it only communicates the motion it had received from another, and loses in itself so much as the other received; which gives us but a very obscure idea of an active power of moving in body, whilst we observe it only to transfer, but not to produce any motion. So that it seems to me, we have from the observation of the operation of bodies by our senses but a very imperfect obscure idea of

of a penny, is easily perceived. In like manner, I can form a direct notion of a polygon of a thousand equal sides and equal angles. This direct notion cannot be more distinct when conceived in the mind, than that which I get by sight when the object is before me; and I find it so indistinct that it has the same appearance to my eye, or to my *direct* conception, as a polygon of a thousand and one, or of nine hundred and ninety-nine sides. But when I form a *relative* conception of it, by attending to the relation it bears to polygons of a greater or less number of sides, my notion of it becomes distinct and scientific, and I can demonstrate the properties by which it is distinguished from all other polygons. From these instances it appears, that our relative conceptions of things are not always less distinct, nor less fit materials for accurate reasoning, than those that are direct; and that the contrary may happen in a remarkable degree."

Reid's Essays on the Active Powers of Man.

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of active power, since they afford us not any idea in themselves of the power to begin any action either of motion or thought." He thinks it evident, however, "that we find in ourselves a power to begin or forbear, continue or end, several actions of our minds and motions of our bodies, barely by a thought or preference of the mind ordering, or, as it were, commanding, the doing or not doing such or such a particular action. This power which the mind has thus to order the consideration of any idea, or the forbearing to consider it, or to prefer the motion of any part of the body to its rest, and *vice versa*, in any particular instance, is that which we call *will*. The actual exercise of that power, by directing any particular action, or its forbearance, is that which we call *volition* or *willing*.

117 Whence it follows, that only such beings as have will and understanding can possess real power.

According to Mr Locke, therefore, the only clear notion or idea we have of power, is taken from the power which we find in ourselves to give certain motions to our bodies, or certain directions to our thoughts; and this power in ourselves can be brought into action only by willing or volition. This is exactly our doctrine; where we have endeavoured to prove, that without the consciousness of actual energy in ourselves, we never could have acquired any notion at all of power from observing the changes which take place among external objects. But if this be so, if the *power*, of which alone we know any thing, can be brought into action only by willing or volition, and if will necessarily implies some degree of understanding, as in us it certainly does, it comes to be a question of the first importance, whether any being which possesses not will and understanding can be possessed of real power, or be the efficient cause of any action. This question we feel ourselves compelled to answer in the negative. If *we* had not will, and that degree of understanding which will necessarily implies, it is evident that we could exert no power, and consequently could have none: for power that cannot be exerted is no power. It follows also, that the power, of which alone we can have any distinct notion, can be only in beings that have understanding and will. Power to produce any effect, implies power not to produce it; and we can conceive no way in which power may be determined to one of these rather than the other in a being that has not will. We grow from infancy to manhood; we digest our food, our blood circulates, our heart and arteries beat; we are sometimes sick and sometimes in health: all these things must be done by the power of some agent, but they are not done by our power. And if it be asked how we know this? the answer is, because they are not subject to our will. This is the infallible criterion by which we distinguish what is our doing from what is not; what is in our power from what is not. Human power can be exerted only by will: and we are unable to conceive any active power to be exerted without will. If, therefore, any man affirms that a being may be the efficient cause of an action which that being can neither conceive nor will, he speaks a language which we do not understand. If he has a meaning, he must take the words *power* and *efficiency* in a sense very different from ours: for the only distinct notion, indeed the only notion which we can form, of real efficiency, is a relation between the cause and effect similar to that between us and our voluntary actions. It seems therefore most probable, that such beings only as have some degree of understanding and will can possess active power, and that inanimate beings must be merely passive. Nothing which we perceive without us affords any good ground for ascribing active power to any inanimate being; and we can as little conceive such a being possessed of power as we can conceive it capable of feeling pain. On the other hand, every thing which we discover in our own constitution, leads us to think that active power cannot be exerted without will and intelligence: and to affirm that it can, is to affirm what to us at least is a contradiction in terms.

118 An objection obviated.

To this reasoning, which is Dr Reid's *, and which to us appears unanswerable, we have heard it objected, that a man born blind has the same evidence for the non-existence of colour that is here urged for the impossibility of power being exerted without will and understanding. If the objection had not been made by a very acute man, we should have deemed it altogether unworthy of notice; for between the two cases supposed to be similar there is hardly any analogy. A man born blind has no notion whatever of colour. If you describe it to him in the best manner you can, and refer it to any of the senses which he possesses; if you say that it is the object of feeling, and that by feeling it one may perceive things at the distance of many miles; the blind man has reason to say that you are uttering a proposition which he knows with the utmost certainty cannot possibly be true. But if you tell him that colour is the object of the sense of sight, a sense which he possesses not; that it has not the least resemblance to the objects of the other senses; and that persons endowed with the sense of sight perceive coloured objects at the distance of many miles; the blind man cannot know whether what you say be true or false, because he has no idea or conception of the things of which you speak. This is not the case with respect to power; for every man who has reflected on the operations of his own mind has a very distinct notion of power, and knows perfectly, that to the actual exertion of the only power which he can conceive, will and understanding are necessary. Should it be said that there may be power altogether different from that of which we have a distinct conception, we think it sufficient to reply, that of a thing which cannot be conceived nothing can be either affirmed or denied: that activity exerted without will and understanding ought not to be called an exertion of *power*, because power is the name already appropriated to the attribute of a being by which he can do certain things if he wills; that as we can form no notion of a real efficient cause which has not will and understanding, so we have no reason to believe that such a cause anywhere exists; and to say that power, such as we can conceive, may be exerted without will and understanding, is as great an absurdity as to say that there may be velocity without space.

* See Essays on the Active Powers of Man.

But if active power, in its proper meaning, requires a subject endowed with will and intelligence, what shall we say of those active powers which philosophers teach us to ascribe to matter, the powers of corpuscular attraction, magnetism, electricity, gravitation, and others? These powers, as they are called, shall be considered when we treat of the nature and source of corporeal

Truth. poreal motion. In the mean time, it is sufficient to observe, that whatever the agents may be in the operations of nature, whatever the manner of their agency or the extent of their power, they depend upon the First Cause, and are all under his controul.

Chap. VII. *Of* Truth, *and the different* Sources *of* Evidence.

Sect. I. *Of Truth.*

By pursuing these inquiries in the order which to us appears most natural, we are now led to the contemplation of those faculties of the human mind of which *truth* is properly the object. But what is *truth?* This was a famous question among the Greek sophists; which had been so often agitated, and to which so many absurd answers had been given, that it came at last to be doubted by men of the world whether a satisfactory answer could be given, or indeed whether the matter was worthy of investigation. It is well known, that among the ancient philosophers there was a sect called from their principles *Sceptics*, and from their founder *Pyrrhonians*, who openly avowed their opinion that *truth*, like virtue, is nothing but a name; that all things are equally true, or rather equally doubtful; and that it is in vain for man to hope for certainty in any inquiry in which he can be engaged. Such scepticism as this no modern philosopher has professed; but many have had enough of it to make sober men hesitate about defining truth, and even insinuate that of truth no definition can be given. This surely is a mistake. If truth cannot be defined, it still wanders at large and in disguise, and vain must be the pursuit of every man who endeavours to obtain it; he is pursuing he knows not what.

Of Truth.

119 Truth defined.

So obvious and so solid is this reflection, that almost every philosopher of merit who has lately written on the nature of evidence has begun his work, if not with a formal definition, with something at least equivalent to a definition of the object of his pursuit. To repeat all these definitions could serve no other purpose than to swell this article to a disproportioned bulk, and to perplex perhaps the mind of the reader. We shall therefore content ourselves with that which is given by Mr Wollaston. "Those propositions (says he) are true which represent things as they are: or truth is the conformity of those words or signs by which things are expressed to the things themselves." Notwithstanding the objections of a very learned and acute writer (w), this is the best definition of *truth* which we have met with in any language. It is concise

(w) Dr Tatham having asked with a contemptuous air, How imperfect and illogical is the definition of truth given by Wollaston? proceeds, though not to define, to describe or characterize it himself. "Truth (says he) is of the nature and essence of God, like him *incomprehensible* in the whole, and *ineffable* in its sublimer parts. For these and other reasons it cannot admit of an *adequate definition.* And who, in the beginning of his researches, should presume to define that which, after all his longest and best conducted labours, he can only hope partially, and often imperfectly, to comprehend; and of which an important part can neither be *directly* expressed nor *directly* understood? We may indeed esteem ourselves highly favoured by the Author and Finisher of all truth, if at the end of our researches, we shall be able any way to understand, to define, and to apply, a few particular portions and detachments of it, and to guard them from ERROR and corruption. When upon a solemn occasion the question was put to our Lord by a Roman governor, *What is* TRUTH? though it was what he fully and perfectly knew, and what he came purposely and professedly to teach, he did not define it. He knew that definition was never the best method of instruction; and that in its common use and application it was seldom the friend of truth. Philosophically viewed, words do not constitute truth; they are only the vocal instruments by which it is communicated, or the written signs by which it is recorded. By an inquirer, therefore, things are to be examined rather than words defined. By a teacher, things are to be conveyed by words in some form or other, which are doubtless to be explained to the understanding, if not sufficiently understood before. But *explanation* is one thing, and *definition* quite another. Explanation is the *first* office of a teacher: Definition, if it be good, is the *last* of the inquirer, after the truth be found; and is then the most *advantageously* employed by the teacher, when his previous instructions have prepared him for it. God is a mind, and TRUTH is consequently an *attribute* of MIND. To the SUN, declaring at his rising a marvellous instrument, He by whom all things were made hath delegated the power of enlightening the *material* system: whilst he hath reserved to HIMSELF the office which is more suitable to his nature, of giving light and knowledge, by his eternal TRUTH, to the *mind* of man. But whether he acts through the instrumentality of his creatures, or more *immediately* from himself, he is uniform and consistent in his operations; so that one part of his divine economy is always illustrative of another. As the SUN sheds his *light* over the material creation to be apprehended by the eye, TRUTH is the *light* shed down from heaven to be apprehended by the intellect, given to illumine every subject, natural and moral, corporeal and spiritual, so far as they are qualified by their different natures to convey it to the human mind, or rather perhaps so far as the human mind is qualified to receive it from them." *The Chart and Scale of Truth*, vol. i.

This passage, of which some parts are certainly not remarkable for perspicuity, seems to be descriptive, not of *truth* in the common acceptation of the word, but of *all knowledge* human and divine, of which indeed no adequate definition can be given. *Truth*, as here used, seems to be opposed to *ignorance;* as used by Mr Wollaston and others, it is opposite to *falsehood.* In this last sense it may certainly be *explained*, if not defined; and if the learned lecturer will allow that Mr Wollaston has given a good *explanation* of the word *truth* as opposed to *falsehood*, we shall not quarrel with him or any man about the propriety of an expression. We have called it a *definition* of truth; because it was so called by the author from whom it is taken.

Of Truth. cise and perspicuous. It comprehends all kinds of truth, as well that which is merely mental, the subject of silent contemplation, as that which is communicated either by written language or by the living voice: and it makes truth itself immutable, as depending not upon the arbitrary constitution of this or that individual, or even of the whole human race (x), but upon the nature of things as established by their Almighty Creator.

120 Every proposition either true or false.

According to this definition, every proposition which can be expressed or apprehended is necessarily either true or false, whether its truth or falsehood be perceived or not either by him who hears or by him who utters it. All propositions are either affirmative or negative; but before any thing can with certainty be affirmed or denied of another, we must know those things as they are in themselves, as well as the established use of the signs by which they are expressed. He who affirms or denies without this knowledge, speaks at random, and has no distinct meaning.

121 Every human faculty concerned in the acquisition of truth.

Every faculty which we possess is in some way or other an instrument of knowledge; for we know by our senses, by our memory, and by our intellect. Every one of our faculties, therefore, is concerned in the acquisition of truth, and furnishes the mind with the materials of propositions. These propositions are indeed of various kinds; but they are all certainly true or certainly false, though the *certainty* of the truth or falsehood of every one it is not always in our power to perceive.

122 Diversity of belief affects not the truth of what is believed.

When a man affirms that red is a quality inherent in a soldier's coat, he utters a proposition which every one of the vulgar firmly believes to be true, but which every philosopher knows to be false. This diversity of belief, however, affects not the truth of the proposition itself. All mankind know that it is either true or false, independent of them or their perceptions; and it is easy, by a few optical experiments and by an explanation of terms, to convince them all, that what they have agreed to call *red* is no quality inherent in external objects, but only a sensation caused by the impulse of certain rays of light reflected from certain objects to the eye of the percipient. The contrariety therefore in this case of vulgar to philosophical belief, does not result from any ambiguity in the nature of truth itself, but from the different means of perception which the clown and the philosopher possess.

Again, Were a man looking at a red and a green object, to affirm that they are both of the same colour, he would affirm what in one sense may be true, what in another is undoubtedly false, and what in a third may be either true or false. If it be his meaning that the two objects give to him the same sensation, he may know with the utmost certainty that what he says is true; if he mean that they affect all mankind precisely as they affect him, he utters what all mankind with the most absolute certainty know to be false; if he mean that the texture of the two bodies (that particular disposition of parts on their surfaces which makes them reflect certain rays of light and absorb others) is exactly similar, so as that the one must reflect the very same kind of rays with the other, he utters what all mankind must *believe* to be false, though still it is *possible* that what he affirms may be true. This diversity of belief affects not the truth itself. The two objects are what they are by whomsoever perceived, or whether perceived or not: the rays of light reflected by each are what they are, whether they fall upon this, upon that, or upon any eye; and the sensation communicated to this singular man is certainly what he is conscious it is, as those of the rest of mankind are with equal certainty what they are conscious of. This being the case, it is obvious and undeniable, that the organs of sight in this individual of the human race are somehow differently formed from those of other men: and the only question which can occasion a doubt in the mind of the sceptic is, whether his or their eyes be so formed as to represent things falsely? for that by the one or the other things are falsely represented, is as evident as that two contradictory propositions cannot both be true. Now, though, for any thing we know it is certainly possible, as to us it appears not to imply any contradiction, that the eyes of but one man are formed in a manner suitable to their objects, whilst the eyes of all other men are formed to deceive them; yet the contrary is so highly probable, that no man really doubts of it any more than he doubts whether three and two be equal to five.

12[illegible] Why s[illegible] truths [illegible] said to [illegible] absolut[illegible] and ot[illegible] morally certain.

This last proposition is indeed said to express a truth absolutely certain, whilst the former expresses a truth which is called morally certain: not that there is any difference or degrees of certainty in the nature of truths themselves; the only difference is in our power of perceiving them. That three and two are equal to five, is

(x) Dr Beattie, in his elegant essay, has given a definition of truth very different from this, though it is possible that his meaning may be the same with Mr Wollaston's. "I account that to be *truth* (says he) which the constitution of our nature determines us to believe; and that to be *falsehood* which the constitution of our nature determines us to disbelieve." But if truth be really *immutable*, as he teaches or wishes to teach, it must depend upon the nature of things, and not upon the instinctive impulse of any particular constitution. It is always difficult, often impossible, to distinguish between the constitution of our nature, as it came from the hand of God, and the same constitution as it is moulded by arbitrary and capricious associations of our own. A sincere member of the church of Rome certainly believes the doctrine of transubstantiation. How he may do so we have already shown. Were all mankind sincere members of that church, it would be said and thought, "that the constitution of human nature determines men to believe transubstantiation:" a doctrine which, though it is rejected by millions, Pere Buffier has laboured hard to reconcile with common sense. Yet it is certain that the same body cannot be in different places at the same time; and that therefore transubstantiation must be false, though believed by all mankind. Our *believing* any thing does not make it true, nor our *disbelieving* any thing make it false. We must, indeed, *act* according to our belief; but in every instance truth and falsehood would have been what they are, though we had never existed.

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is said to be an absolute truth; because we perceive the whole of it as it is in itself, and are convinced that every intelligence from the highest to the lowest who understands the terms in which it is expressed perceives it as we do: whereas of *moral* or *physical* truths, as they are called, we only perceive a part, and may therefore mistake for want of evidence. Thus, in the case of the two objects exhibiting the same colour to one man, whilst they exhibit different colours to all other men, could we see into the objects themselves, and comprehend them immediately with our intellect as we comprehend our own ideas, it might, and no doubt would, appear as palpable a contradiction to say that the particular disposition of the parts on the surfaces, which reflect the rays of light, are the same in both, as it is now to affirm that three and two are not equal to five. Between truth and falsehood there is no medium. All truths are in *themselves* equally certain; and to the Supreme Being, who knows the nature of every thing more fully and intimately than we know our own ideas, they all *appear* equally certain: but yet we may without absurdity speak of *probable* truth as well as of *certain* truth, provided always that we make the difference to result, not from the nature of things, but from the power of our understanding, which comprehends the one kind of truth wholly and the other only partially.

24 some s are to be al and ssary, t s are dered mpo- and ngent.

There is another division made of truth into that which is eternal and necessary, and that which is temporary and contingent. Though we do not approve of applying the epithets *temporary* and *eternal* to any thing but real existences, yet as this manner of speaking has been used by all philosophers, we shall give instances of each kind of truth, and endeavour to ascertain in what the distinction consists. "The three angles of a plain triangle are equal to two right angles," is a proposition expressive of a necessary and eternal truth. "The world exists," is a contingent and temporary truth. Here it is obvious, that if both these propositions be true, there is no distinction between them, so far as mere *truth* is concerned; for truth admits not of degrees of comparison. It is however said, that the first proposition depends not upon time, or will, or any thing else; and that the Supreme Being himself could not make it false: whereas it is certainly possible, that he who created the world could annihilate it, and thus reduce what is now a truth to an absolute falsehood. This difference between the two propositions is thought a sufficient ground for calling the former a *necessary* and *eternal* truth, and the latter a *temporary* and *contingent* truth. But is the difference itself real? In the present instance we cannot think that it is: for if the right angles and triangles, which constitute the materials of the former proposition, be real corporeal things, they may be annihilated as well as the rest of the world; and then the truth of the proposition will cease, for there can be neither equality nor inequality between nonentities. If the angles and triangles be merely ideas in the mind of a rational being, it is not to be denied that the proposition must be true, independent of all *will*, whenever those ideas exist, i. e. whenever right angles and triangles are *thought upon*; but if all reasonable creatures were to be annihilated, and the Supreme Being never to think of triangles, the proposition would unquestionably cease to be either true or false. The world may indeed be annihilated; but it certainly is not annihilated whilst any one creature exists to contemplate even that which is called *necessary* and *eternal* truth: and therefore whilst any truth exists in a mind not divine, it must be necessarily true that the world exists; for the individual being by which truth is perceived would then constitute the whole world.

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But if in a somewhat different manner we compare the former of these propositions with this, "The solar system consists of the sun and at least seven primary planets," we shall at once perceive the difference between necessary and contingent truths. Both propositions we know to be true at this moment: but there is this difference between them, that a plain triangle can neither actually exist at any period of duration, nor be conceived by any one mind divine nor human, of which the three internal angles are not precisely equal to two right angles; whereas the solar system may easily be conceived, and might certainly have been formed, with a smaller number of primary planets rolling round the central fire. This needs no proof; as it is well known, that till very lately we conceived the system to consist of the sun and only six primary planets; and it has been already shown, that whatever we can positively conceive may possibly exist. Thus, then, every proposition, of which the contrary is clearly and distinctly perceived to be impossible, is a *necessary* truth; and it may likewise be said to be *eternal*, because at every period of duration it must of necessity when thought upon be perceived to be true: On the other hand, every proposition of which the contrary may be clearly and distinctly conceived, is, if true, only a *contingent* truth, because its contrary might have existed; and it may likewise be called *temporary*, because what might have been false in time past may yet be false in time future.

125 Truth perceived by our rational faculties, which are commonly said to be two, *reason* and *judgment*.

Though all our faculties (our senses, our memory, and our intellect), furnish materials for propositions, and are therefore all subservient to the investigation of truth; yet the perception of truth, as it is in itself, is commonly ascribed to our rational faculties; and these have by Locke and others been reduced to two—reason and judgment. The former is said to be conversant about certain truths, the latter chiefly about probabilities.

126 To which some philosophers have added a third faculty, viz. *common sense*.

Some late philosophers of great merit, dissatisfied with this analysis of the intellect, have added to reason and judgment a third faculty, to which they have given the name of *common sense*, and of which the proper object is such truths as neither admit nor stand in need of evidence. By *common sense* they mean, "that degree of judgment which is common to men with whom we can converse and transact business." Whether the introduction of such a term into metaphysics was proper or improper, we do not think it of importance to inquire. According to this definition of it, which is Dr Reid's, it differs not from the *reason* (Y) and *judgment* of Locke; agreeing with the former when its

(Y) This is expressly acknowledged by Dr Reid. "It is absurd (says that able and candid writer) to conceive

Of Intuitive Evidence and Demonstration.

its object is certain truth, and with the latter when it is conversant about probabilities. Nothing indeed is more evident, than that in the assent of the mind to every proposition, some energy of the judgment is exerted; and upon every proposition not self-evident, reasoning of some kind or other must be employed to procure that assent. Instead therefore of perplexing ourselves and our readers with various analyses of the human understanding, or rather with various names to what after all is perhaps but one individual power, it will surely be of more importance to the cause of truth to examine the different sources of evidence by which the assent of the reason, or judgment, or common sense, is determined.

Under the article LOGIC it was observed, that *intuition*, *experience*, and *testimony*, are each a sufficient *ground* of *judgment*; but they are not the only grounds. *Consciousness* is certainly one source of evidence, perhaps the most complete of any; and, in a low degree, *analogy* is another. Of *consciousness* we have already treated, but of *analogy* we have yet said nothing: and though we might (for an account of *intuition*, *experience*, and *testimony*) refer our readers to the article LOGIC, where they are accurately though concisely explained, we shall, without repeating what has been already said, add a few words on each, as well to complete the present article as to supply the deficiencies of the former.

SECT. II. *Of Intuitive Evidence and Demonstration.*

127 Intuitive evidence, what.

INTUITIVE evidence is that which arises from the comparison of two or more ideas or notions when their agreement or disagreement is perceived immediately, without the intervention of any third idea or notion. Of this kind is the evidence of these propositions: One and four make five *; things equal to "the same thing are equal to one another; the whole is greater than any of its parts;" and in a word, all the axioms in arithmetic and geometry. All these are in reality propositions in which the subject and predicate appear upon comparison to be nothing more than the same thing taken in different views or expressed by different terms. In fact, they are all in some respect reducible to this axiom, "Whatever is, is." We do not say that they are deduced from it; for they have in themselves that original and intrinsic evidence which makes them, as soon as the terms are understood, to be perceived intuitively. And if they be not thus perceived, no deduction of reason will ever confer on them any additional evidence. But though not deduced from the general axiom, they may be considered as particular exemplifications of it; inasmuch as they are all implied in this, that the properties and relations of our clear and adequate ideas can be no other than what the mind clearly perceives them to be.

* *Campbell's Philosophy of Rhetoric.*

128 Every demonstration a series of propositions intuitively evident.

It may perhaps be thought, that if axioms were propositions perfectly identical, it would be impossible by their means to advance a single step beyond the simple ideas first perceived by the mind. And it would indeed be true, that if the predicate of the proposition were nothing but a repetition of the subject under the same aspect, and in the same or synonymous terms, no conceivable advantage could be made of it for the furtherance of knowledge. Of such propositions as these, for instance, "seven are seven, eight are eight, the three angles of a triangle are the three angles of a triangle, two right angles are two right angles," it is manifest that we could never avail ourselves for the improvement of science: But when the thing, though in effect coinciding, is considered under a different aspect; when that which is single in the subject is divided in the predicate, and conversely; or when what is a whole in the one is regarded as a part of something else in the other; such propositions lead to the discovery

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conceive that there can be any opposition between reason and common sense. It is indeed the first-born of reason; and as they are commonly joined together in speech and in writing, *they are inseparable in their nature.* We ascribe to reason two offices or two degrees: the first is to judge of things self-evident; the second to draw conclusions that are not self-evident from those that are. The first of these is the province, and the sole province of common sense; and therefore it *coincides with reason in its whole extent*, and is only *another name* for one branch or one degree of reason." Pere Buffier talks nearly the same langnage; but Dr Beattie expresses himself very differently. "That there is a real and essential difference between these two faculties; that common sense cannot be accounted for by being called the *perfection of reason*, nor reason by being resolved into *common sense;* will appear (he thinks) from the following remarks: 1. We are conscious, from internal feeling, that the energy of understanding, which perceives intuitive truth, is different from that other energy which unites a conclusion with a first principle by a gradual chain of intermediate relations. 2. We cannot discern any necessary connexion between reason and common sense. Nay, he says, "That we often find men endued with the one who are destitute of the other:" and he instances dreams and certain kinds of madness where this is the case; adding, that a man who believes himself made of glass, shall yet reason very justly concerning the means of preserving his supposed brittleness from flaws and fractures." Surely these are strange remarks. Dreams and madness have hitherto been supposed to originate in the imagination, or, as it was denominated by the ancient philosophers, the *phantasia:* and when the ideas or forms which are there treasured up are disarranged or absurdly compounded, a dreaming sane man or a walking madman, if he reason at all, must reason from absurd principles: not, however, through any defect of common sense, but from a disorder in that region of the brain, upon which the phantasia more immediately depends. Of his first remark, we can only say, that to us it appears to be the reverse of truth. In every proposition which admits of demonstration, *we* are conscious that the conclusion is united with the first principle by a repetition of the very same energy of the understanding which perceives intuitive truth. That this is the case in every one of Euclid's demonstrations, we appeal to every mathematical reader; and why it must be so, we shall by and by endeavour to evince.

Of intuitive evidence and demonstration.

discovery of innumerable and apparently remote relations. It is by the aid of such simple and elementary principles that the arithmetician and the algebraist proceed to the most astonishing discoveries. Nor are the operations of the geometrician essentially different: for to this class belong all propositions relating to number and quantity; that is, all which admit of mathematical demonstration. If the truth of a mathematical proposition be not self-evident; in other words, if the subject and predicate do not appear at first sight to be different names for the same thing, another term must be found that shall be synonymous to them both. Thus, to prove that the three internal angles of a right-lined triangle are equal to two right angles, I produce the base of the triangle; and by a very short process I discover that the exterior angle so formed is equal to the two interior and opposite angles. By a process equally plain and short, I perceive that the exterior angle and the interior adjacent angle are equal to two right angles: But I have already seen, that the exterior angle is neither more nor less than the two interior and opposite angles under a different aspect; whence it appears that the three internal angles of the triangle are nothing else than two right angles under a different aspect. In a word, all demonstration is founded on first principles or primary truths, which neither admit nor stand in need of proof, and to which the mind is compelled to give its assent by a bare intuition of the ideas or terms of which these primary truths are composed. Nothing is susceptible of demonstration, in the rigid sense of the word, but general, necessary, and eternal truths; and every demonstration is built upon intuition, and consists in a series of axioms or propositions of the very same kind with the first principle or truth from which the reasoning proceeds. That propositions formerly demonstrated are taken into the series, doth not in the least invalidate this account; inasmuch as these propositions are all resolvable into axioms, and are admitted as links in the chain; not because necessary, but merely to avoid the useless prolixity which frequent and tedious repetitions of proofs formerly given would occasion. But it is obvious that such truths only as result from the comparison of ideas and notions are necessary; and of course that such truths only are capable of strict demonstration. The truths which relate to real existences are all contingent, except that which affirms the existence of the Supreme Being, the Parent of all truth.

The mathematical sciences, categorical logic, and that part of metaphysics which demonstrates the being of God, are therefore the only branches of human knowledge which admit of strict demonstration. The longest demonstration in the mathematical sciences may be traced to this general and necessary truth, "Whatever is, is," or to some particular exemplification of it: the longest train of categorical syllogism terminates in this general principle, "What is affirmed or denied of a whole *genus*, may be affirmed or denied of all the *species*, and all the *individuals* belonging to that genus:" and the metaphysical demonstration of the being of God rests upon this foundation, "Whatever had a beginning, had a cause." That these are truths absolutely certain, which can neither be proved nor called in question, every man may be satisfied, merely by attending to the ideas or notions which the terms of each proposition express. The two first are merely identical propositions, of the truth of which no man has ever pretended to doubt; and though the last is not identical, it is a necessary and self-evident truth, as its contrary implies, that in the same thing there is power and no power, change and no change, action and inaction, at the same instant.

129 It is by intuition that we acquire all our notions of relation.

Before we dismiss the subject of intuition, it may not be improper to observe, that it is by this faculty or power of the mind contemplating its ideas, and comparing one idea with another, that we acquire all our notions of relation: such as *identity* and *diversity*, *resemblance*, *coexistence*, relations of *space* and *time*, relations of *quantity* and *number*, of a *cause* to its *effect*, and many more which it would be useless as well as tedious to enumerate.

Sect. III. *Of Experience and Analogy.*

130 Experience, the result of repeated observations.

It has been just observed, that intuition and demonstration are applicable only to general and necessary propositions, of which the contrary are not only false, but absurd and impossible. The great business of life, however, is with facts and contingent truths, which admit not of demonstration, but rest upon other evidence. The senses, external and internal, are the inlets to all our knowledge of facts; and the memory is the storehouse where that knowledge is preserved. Of what a man sees or feels, he can at the instant of seeing or feeling entertain no doubt; and whilst the ideas of what he has seen or felt, with all their associated circumstances, remained vivid and distinct in his memory, he is conscious that he possesses so much real knowledge. But all our knowledge, as it is derived from the senses, is of particular facts or particular truths; and the man who has in certain circumstances observed one particular phenomenon, for the existence of which he perceives no *necessity*, has not sufficient ground to conclude, that in similar circumstances similar phenomena will always occur. Milton, who surpassed the greater part of his cotemporaries in philosophical science almost as far as he has surpassed all succeeding poets in the sublimity of his genius, represents Adam, when first falling asleep, as under apprehensions that he was about to sink into his original state of insensibility:

———————" Gentle sleep
" First found me, and with soft oppression seiz'd
" My droused sense, untroubled; though I thought
" I then was passing to my former state
" Insensible, and forthwith to dissolve."

Apprehensions similar to these would take place in his mind when he first perceived that darkness had overspread the earth. In his circumstances, he could have no ground to expect that the sun when once set would rise again to relume the world, as he had not then experienced the alternate succession of light and darkness, and probably knew not whence light proceeds. After some time, however, having observed day and night regularly to succeed each other, these two appearances, or the ideas of them, would be so associated in his mind, that each setting sun would suggest the idea of next sunrising, and lead him to expect that glorious

Of Experience and Analogy.

glorious event with the utmost confidence. He would then consider the alternate succession of day and night as a law of nature, which might be affirmed in a proposition expressive of a certain truth.

131 Is the only evidence that we have for all the general truths in physics, even those which we think intuitively certain.

This continued observation of the same event happening in the same or similar circumstances, is what we call *experience*; and it is the only evidence which we have for all the general truths in physics, even for those which we are apt to think intuitively certain *. Thus, that *milk* is white, and that *gold* is yellow, are supposed to be universal and necessary truths: but for any thing that we know, they may be particular truths; and they are certainly contingent, as the contrary to either of them may be supposed without absurdity. We have indeed always observed the milk of animals of every species *white*; and therefore the idea of *white* becomes a necessary part of our *idea* of the substance milk, of which we call whiteness an essential property. This, however, respects only the milk of those animals with which we are acquainted. But since the milk of all the animals with which we are acquainted, or of which we have heard, is white, we can have no reason to suspect that the milk of any new and strange animal is of any other colour. Also, since wherever there has been the specific gravity, ductility, and other properties of *gold*, the colour has always been *yellow*; we conclude that these circumstances are necessarily united, though by some unknown bond of union, and that they will always go together.

* *Campbell's Philosophy of Rhetoric*; and *Priestley's Remarks on the Drs Reid*, &c.

132 Difference between experience and analogy.

The proper proof, therefore, of such universal propositions as "milk is white," "that gold is yellow," or, "that a certain degree of cold will freeze water," consists in what is called an induction of *particular facts* of precisely the same nature. Having found, by much and various experience, that the same events never fail to take place in the same circumstances, the *expectation* of the same consequences from the same previous circumstances is necessarily generated in our minds; and we can have no more suspicion of a different event than we can separate the *idea* of *whiteness* from that of the other properties of *milk*. When the previous circumstances are precisely the same, we call the process of proof by the name of *induction*, and expect the event from *experience*: but if they be not precisely the same, but only bear a considerable resemblance to the circumstances from which any particular appearance has been found to result, we call the argument *analogy*; and it is stronger in proportion to the degree of resemblance in the previous circumstances. Thus the milk of all the cows that we have seen, or upon which we have made the experiment, having been found nourishing, we confidently expect that the milk of all other cows will prove nourishing likewise; and this confidence of expectation is the result of uniform experience. But if, from having found the milk of all the animals with which we are acquainted to be nourishing, however different the nature of these animals; we infer that the milk of any strange animal will likewise be nourishing; the inference is drawn by analogy, and by no means carries with it the conviction of experience. A proof from *real* experience can leave no doubt in the mind (z); an argument from analogy always must. In the one case, we only infer that two events of precisely the same nature, and in precisely the same circumstances, have been produced by the same kind of cause; in the other, we infer that two events similar in most respects, though for any thing that we know dissimilar in others, have been produced by the same kind of cause; and it is obvious that between these cases the difference is great.

133 The evidence of analogy inferior to that of experience.

Thus, after having observed that all the projectiles to which we have paid any attention—a stone thrown from the hand, a ball from a gun, and an arrow from a bow—describe a certain curve, and are impelled in that curve by two powers acting in different lines of direction which form with each other a certain angle, we infer that all projectiles which on the surface of the earth describe the same curve are impelled by the same or similar powers acting in the same or similar lines of direction. This inference is the result of experience, and carries with it the fullest conviction to the mind. But when, from having observed that the curves described by the planets are of the same kind with those described by projectiles on the earth, Sir Isaac Newton inferred that these vast bodies are impelled in their orbits by forces of the very same kind, and acting in the same manner with the forces which impel a ball from a cannon or an arrow from a bow, his argument was founded only on analogy; and even that

(z) We say from *real* experience; because what is often taken for *experience*, and to human eyes has that appearance, is in fact nothing more than *analogy*. Thus a physician may have prescribed to ninety-nine patients labouring under the same disease the same remedy, and always with the same success. If so, he will think that he has experience of its utility, and will prescribe it again with the fullest confidence. Yet in this case he may be disappointed; for though the medicine be the same and the disease the same, there may be something in the constitution of the hundredth patient so different from that of the ninety-nine, that what was salutary to them may be pernicious to him. This does not detract from the evidence of experience; it only shows, that the circumstances of the case in which the medicine failed were different from those in which it succeeded. In such conclusions as are founded on a complete induction and uniform experience, every man expects the event with the last degree of assurance, and regards his past experience as a full *proof* of the future existence of that event: In other cases, where experience has been variable—or apparently variable—he knows that the induction has been incomplete, and therefore proceeds with caution. He weighs the opposite experiments; takes as complete a view as he can of the circumstances in which they were made; considers which side is supported by the greater number of experiments, and inclines to that side with doubt and hesitation. And when at last he fixes his judgment, the evidence exceeds not what is called *probability*. All probability, then, supposes an opposition of experiments and observations, where the one side is found to overbalance the other, and to produce a degree of evidence proportioned to the superiority.

Testimony.

that analogy is very remote. We know by experience that all projectiles which fall under our immediate cognizance are of the very same kind and in the very same circumstances; that every one of them has a tendency, from whatever cause, to the centre of the earth, and is preserved from falling by the force of projection; we know likewise that they are all moved through the medium of the atmosphere, which at the surface of the earth is considerably dense, and that a dense medium must occasion much resistance: But we do not *know* that the planets have a tendency to the centre of the sun, that they are preserved from falling into that luminary by a projectile force, or whether they move through a *medium* or *in vacuo;* so that we are not *certain* that the motion of the planets is perfectly similar to that of terrestrial projectiles in any other circumstance than the form of the curve which they all describe; and from this single case of coincidence no inference can be drawn which carries to the mind absolute conviction.

When a man reasons from *experience*, he infers, that what has uniformly happened hitherto, will happen always in the very same circumstances; or that what is known to be the cause of *various phenomena of the same kind* is the cause of every other phenomenon in *all respects* similar to these. Such an inference is founded on the united and complete evidence of sense, memory, and reason. When a man reasons from *analogy* he infers, that what has *generally* happened hitherto, will happen again in circumstances *nearly similar;* or that what is known to be the cause of various phenomena of the same kind, is the cause of other phenomena in *some respects* similar to these. This inference is likewise founded on the united evidence of sense, memory, and reason: but here the evidence of sense is not complete, and it can be strengthened only by finding more facts of the same or of a similar nature.

SECT. IV. *Of Testimony.*

134 Mankind are prone to give credit to the testimony of each other.

THE last source of evidence which we proposed to consider is *testimony*, or the report of men concerning events which have fallen under the observation of their senses. That we are all ready to believe the information which we receive from the testimony of our fellow creatures is undeniable; and indeed without such belief every man's knowledge of facts and events would be confined to those only of which he himself had been a personal witness. In that case, no man who had not travelled would believe that there are such cities as Rome and Constantinople; and no man whatever could now believe that such heroes as Hannibal and Cæsar had ever existed.

Between words and things there is no natural connexion; and though we are all accustomed to give to things the names by which they are known in the language that we speak, and to express their mutual relations by the words appropriated for that purpose; yet it is obviously impossible to denote one thing by the name of another, and to express by words relations that have no existence. This being the case, it may be asked upon what principle we give credit to human testimony? To this question various answers have been given, which have produced much controversy on one of the most important subjects which can employ the mind of man.

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135 The reason assigned by Hume for this propensity

"We may observe (says Mr Hume *), that there is no species of reasoning more common, more useful, and even necessary to human life, than that which is derived from the testimony of men and the reports of eye-witnesses and spectators. This species of reasoning perhaps one may deny to be founded on the relation of cause and effect. I shall not dispute about a word. It will be sufficient to observe, that our assurance in any argument of this kind is derived from no other principle than our observation of the veracity of human testimony, and of the usual conformity of facts to the reports of witnesses. It being a general maxim that no (A) objects have any discoverable connexion together, and that all the inferences which we can draw from one to another are founded merely on our experience of their constant and regular conjunction; it is evident that we ought not to make an exception to this maxim in favour of human testimony, whose connexion with any event seems in itself as little necessary as any other. Were not the memory tenacious to a certain degree; had not men commonly an inclination to truth, and a principle of probity; were they not sensible to shame when detected in falsehood: Were not these, I say, discovered by *experience* to be qualities inherent in human nature, we should never repose the least confidence in human testimony. And as the evidence derived from witnesses and human testimony is founded on past experience, so it varies with the experience, and is regarded either as *a proof* or *probability*, according as the conjunction between any particular kind of report and any kind of object has been found to be constant or variable. There are a number of circumstances to be taken into consideration in all judgments of this kind; and the ultimate standard by which we determine all disputes that may arise concerning them, is always derived from experience and observation. The reason why we place any credit in witnesses and historians, is not derived from any *connexion* which we perceive *à priori* between testimony and reality, but because we are accustomed to find a conformity between them. But when the fact attested is such a one as has seldom fallen under our observation, here is a contest of two opposite experiences; of which the one destroys the other as far as it goes, and the superior can only operate on the mind by the force which remains. The very same principle of experience which gives us a certain degree of assurance in the testimony of witnesses, gives us also, in this case, another degree of assurance against the fact which they endeavour to establish; from which contradiction there necessarily arises a counterpoise, and mutual destruction of belief and authority."

* *Essay on Miracles.*

136 confuted,

This account of the origin of faith in testimony has been and

(A) Is there then no discoverable connexion between a tree and the field in which it grows; between a man and his clothes; between an author and his work; between a sceptic and paradoxes? Surely all these are correlates, and necessarily suggest the ideas of each other.

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been controverted with much success by the Doctors Campbell and Reid. "That the evidence of testimony is derived solely from experience (says the former of these writers*), is at least not so incontestable a truth as Mr Hume supposes it; that, on the contrary, testimony hath a natural and original influence on belief antecedent to experience, will, I imagine, easily be conceived. For this purpose, let it be remarked, that the earliest assent which is given to testimony by children, and which is previous to all experience, is, in fact, the most unlimited; that by a gradual experience of mankind, it is gradually contracted, and reduced to narrower bounds. To say, therefore, that our diffidence in testimony is the result of experience, is more philosophical, because more consonant to truth, than to say that our faith in testimony has this foundation. Accordingly, youth, which is unexperienced, is credulous; age, on the contrary, is distrustful. Exactly the reverse would be the case were this author's doctrine just." This is a complete confutation of the reasoning of Mr Hume: but in order to prevent all cavilling, it is to be wished that the very acute author had explained more fully what he means by saying, that testimony hath a *natural* and *original* influence on belief; for these words may be taken in different senses, in one of which what he affirms is true, and in another false.

*Dissertation on Miracles, and The Philosophy of Rhetoric.

Dr Campbell's omission is amply supplied by Dr Reid, who gives † the following account of testimony, and of the credit which it obtains. "The wise and beneficent Author of nature, who intended that we should be social creatures, and that we should receive the greatest and most important part of our knowledge by the information of others, hath, for these purposes, implanted in our nature two principles that tally with each other. The first of these principles is a propensity to speak truth, and to use the signs of language so as to convey our real sentiments. This principle has a powerful operation even in the greatest liars; for where they lie once, they speak truth a hundred times. Truth is always uppermost, and is the natural issue of the mind. It requires no art or training, no inducement or temptation, but only that we yield to a natural impulse. Lying, on the contrary, is doing violence to our nature, and is never practised even by the worst men without some temptation. Speaking truth is like using our natural food, which we would do from appetite, although it answered no end; but lying is like taking physic, which is nauseous to the taste, and which no man takes but for some end which he cannot otherwise attain.—When we are influenced by any motive, we must be conscious of that influence, and capable of perceiving it upon reflection. Now, when I reflect upon my actions most attentively, I am not conscious that in speaking truth I am influenced on ordinary occasions by any motive moral or political. I find that truth is always at the door of my lips, and goes forth spontaneously if not held back. It requires neither good nor bad intention to bring it forth, but only that I be artless and undesigning. There may indeed be temptations to falsehood, which would be too strong for the natural principle of veracity, unaided by principles of honour or virtue; but where there is no such temptation, we speak truth by *instinct*. By this instinct, a real connexion is formed between our words and our thoughts; and thereby the former become fit to be signs of the latter, which they could not otherwise be."

† Inquiry into the Human Mind, &c.

Such is the account which Dr Reid gives of the truth of human testimony: and he adds, that there is another original principle implanted in us by the Supreme Being, to tally with it, viz. a disposition to confide in the veracity of others, and to believe what they tell us. "This (he says) is the counterpart to the former; and as that may be called the *principle of veracity*, we shall, for the want of a more proper name, call this the *principle of credulity*. It is unlimited in children, until they meet with instances of deceit and falsehood; and retains a very considerable degree of strength through life."

It is ever with extreme reluctance that we controvert the opinions of this able writer; and that reluctance cannot be lessened in the present instance, when we are conscious that great part of what he says is unanswerable. That truth is always at the door of the lips; that it requires no effort to bring it forth; that in ordinary cases men speak truth uninfluenced by any motive moral or political; that the greatest liars speak truth a hundred times where they lie once; and that lying is never practised by the worst men without some temptation, are positions which daily experience renders it impossible to question: But notwithstanding this, we do not think that truth is spoken by an *instinctive* principle; because it is inconceivable that instinct should teach the use of arbitrary and artificial signs, such as the words of every language undoubtedly are; or that between such signs and ideas any *instinctive* connexion should ever be formed. "Truth (as we have defined it) is the conformity of those words or signs by which things are expressed to the things themselves;" and things themselves are what they are, independent of us, our instincts, and perceptions. When we have precise and adequate ideas of objects, and when those ideas are related to one another as the objects themselves are related, we are in possession of mental truth; and in this case there is a *real* and *natural* connexion between the signs and the things signified: for we cannot frame original and simple ideas which have no archetype in nature; nor can *one* object, distinctly perceived, generate in our minds the ideas that are generated by *other* objects. Here external things are the objects, and ideas are the signs, which, when they are in conformity to the things signified by them, constitute truth.

137 The true reason assigned.

But in human testimony, the ideas in the mind of the speaker are the things signified, and the words of language are signs by which they are expressed; and when these things and signs are in conformity to each other, the words uttered express so much truth.—Now, though in this case there is no *natural* connexion between the sign and the thing signified, yet it is obvious, that without a violent effort of the speaker to the contrary they must always be in conformity with each other; because, in every language, there are words appropriated for the purpose of denoting every idea and relation which can be expressed; and in the mind of every man these ideas, relations, and *words*, have been constantly associated from the time that he learned to speak. So intimate is this association, and so impossible to be broken, that whoever will pay sufficient attention to

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to the operations of his own mind, will find that he *thinks* as well as *speaks* in some language; and that in cogitation he supposes and runs over, silently and habitually, those sounds which in speaking he actually utters (B). If this be so, it is impossible that a man without some effort should ever speak any thing but truth: for the *ideas* of what he has seen or heard, &c. are not of his manufacture; they are generated by external objects; and till they be effaced from the memory, they must always, by the law of association, make their appearance there with all their mutual relations, and in their proper dress. In the very act of learning to speak, we necessarily learn to speak the *truth:* for were we not to employ words exactly as they are employed by those with whom we converse, our language (if language it might be called) would be unintelligible: and we could neither declare our wants nor ask relief with any hopes of success. *Children* beginning to speak, may indeed utter untruths without any motive, and merely from mistake; because the ideas and words of children have neither been long nor closely associated: but it is impossible that a *man*, however wicked, should habitually and without motives lie on ordinary occasions, unless the fundamental principles of his nature have been totally altered; unless his brain has been disordered by disease; unless his ideas have been disarranged, and all his original associations broken.

We know indeed by woful experience, that immoral men occasionally utter falsehoods with a view to deceive. But on these occasions they are influenced by some motive either of hope or terror: the falsehood is always uttered with an effort: and so strong is the association between words and ideas, that the truth will at times break out in spite of all their endeavours to suppress it; so that the end or middle of a false narrative, if it be of any length, is commonly inconsistent with the beginning. We entertain a suspicion concerning any matter of fact, when those who relate it contradict each other—when they are but few in number, or of a doubtful character—when they have an interest in what they affirm—when they deliver their testimony with hesitation—or, on the contrary, with too violent asseverations; because these are circumstances which we have generally experienced to accompany false witness. It is likewise with reluctance that we admit a narrative of events entirely different from every thing which hitherto we have seen or heard; because we may not be certain that the narrator is not under some influence to deceive us in matters concerning which we have nothing but his testimony on which to ground our judgment. But in every case where the fact recorded is in itself possible, and attributed to an adequate cause; where a competent (C) number of witnesses had sufficient means of information, and are certainly under no inducement to deceive; testimony is complete evidence, however extraordinary the fact may be; because no fact which is known to have an adequate cause can be so incredible, as that a number of men of sound understandings should act contrary to the fundamental principles of human nature, or be able, if so disposed, to dissolve associations which had been formed in the mind of each from his infancy, and form new ones, all agreeing exactly with one another, but all contrary to truth.

PART II. OF BODY WITH ITS ADJUNCTS.

Chap. I. *Of the* Composition *of* Bodies; *or, of* Matter *and* Form.

HITHERTO we have contemplated only the powers of our minds by which we acquire a stock of ideas, and the various operations of the intellect upon those ideas, as treasured up in the memory or imagination. In the course of the inquiry we have found, that every idea and notion which we have was suggested by something independent of us; and in order to discover what those things are, we have investigated the nature of each sense, as it is by the senses only that we have any communication with the external world. By touch we perceive heat and cold, hardness and softness, figure, solidity, motion, and extension; by the organ of smell, we perceive odours; by the tongue and palate, tastes; by the ear, sounds; and by the sight colours. We have likewise seen, that heat and cold, odours, tastes, sounds, and colours, are mere sensations which have no existence but while they are perceived. On the other hand, hardness and softness, figure and solidity, motion and extension, are neither sensations, nor like sensations; but are conceived to be something ex-

ternal

(B) This seems to have been *Plato*'s opinion; for he calls *thinking* λογον ον αυτη προς αυτην ἡ ψυχη δι εξερχεται περι ων αν σκοπη, "the language by which the soul explains itself to itself when it considers any thing." And *Plotinus* says, Ὁ εν φωνη λογος μιμημα του εν ψυχη, "the vocal words are an imitation of those of the soul." To say that vocal words are an imitation of those of the soul, is to speak inaccurately, and to reverse the process of association; but it affords sufficient evidence, that in the opinion of Plotinus men think as well as speak in words.

(C) Should it be asked what number we call competent, we beg leave to say, that it will be greater or less according to circumstances. In cases where they are not liable to the deceptions of sense, two men of integrity and intelligence deserve equal credit with two thousand; but where there is particular occasion for good organs, whether of sight, hearing, or touch, the greater the number the greater is our security. To this must be added, that as one man is influenced by that which to another would be no motive, a great number of witnesses concurring in the same testimony is always an additional security that they are not under the influence of any latent bias.

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ternal and independent of our faculties, which may operate in a desert wilderness as well as in a populous city, though, for want of sentient beings to operate upon, it cannot in the wilderness produce the same effects as in the city.

138 Of things perceived by the senses the greater part always united.

Of things perceived by the senses we find the greater part always united; for when a man perceives a piece of sealing wax, if he makes use of all his senses, he perceives at once, cold, taste, colour, hardness, roughness or smoothness, figure, solidity, motion or rest, and extension. That the powers or qualities, which in this instance produce the sensations of heat or cold, taste, odour, and colour, are so united to the hardness, figure, solidity, and extension of the wax, as that they cannot exist alone, is evident; because it is impossible to remove any one of these things, or to conceive it removed, without removing with it all the rest. What then is the bond of this union? Do these things necessarily accompany one another, so as that one of them cannot exist without bringing all the rest along with it? No; there is no necessary connexion among them; for by the operation of fire the wax may be rendered liquid, when the *hardness* and *cold* are gone, though every thing else remains the same, or nearly the same, as it was before. By a still further operation of fire the appearance may be entirely changed; and that which was formerly a piece of hard red wax, may be reduced to smoke and ashes, in which there is neither hardness, colour, odour, nor figure; at least there is not in the smoke and ashes *such* hardness, colour, odour, or figure, as was in the wax. The solidity and extension, however, remain; for we perceive ashes and smoke to be extended and solid as much as wax or an adamant; nor is it possible to do any thing with the wax, or with any other sensible object, which shall deprive it of extension or solidity.

139 Some of these things termed *accidents*, and why.

Thus, then, extension and solidity may exist and be perceived, when separated from hardness, colour, and odour; but none of these can exist, or be conceived to exist, independent of extension and solidity. Hardness, colour, odour, taste, and figure, or the things which suggest these notions to us, have with great propriety been termed accidents or qualities; because they cannot exist or be conceived to exist by themselves, but require for their support one common subject. Extension and solidity can exist independent of them; but they cannot exist independent of solidity and extension.

140 Things perceived by the senses, qualities which inhere in a subject called *matter*.

Is then solidity the basis of these qualities, so that they necessarily result from it? No; there are many things solid and extended which are neither hard, nor coloured, nor odorous, nor sapid; which could not be if these qualities were the necessary effect of solidity. Besides, all mankind conceive of solidity and extension as qualities of something else; for we never say that solidity is extended or coloured, or hard or odorous, but that something solid has these qualities: whence it is evident that we consider solidity as a quality itself. In what then does solidity and all the other sensible qualities inhere, since they cannot exist separately, and do not support each other? This is a question which modern philosophers pretend not to answer: but some of the ancients were not so modest. Aristotle and his followers resolved every bodily substance into *matter* and *form*, making matter the basis or *substratum*, and under form comprehending all sensible qualities.

As attempts have been lately made to revive this philosophy, it may not be improper to give a short view of the doctrine of *matter* and *form*, if it were only to discover whether the speculations of Aristotle and his adherents on this subject deserve to be preferred to those of Newton and Locke.

The most perspicuous, and by far the most elegant writer among the moderns who has adopted the ancient philosophy, is Mr Harris; and lest we should be accused by others of doing injustice to a subject above the reach of ordinary comprehension, we shall transcribe so much of what he has said of *matter* and *form* in his Philosophical Arrangements as seems necessary to make our readers understand his meaning as far as it is intelligible.

141 The Peripatetic doctrine concerning matter;

"Matter (says this writer) is that elementary constituent in composite substances which appertains in *common* to them all, without distinguishing them from one another. Every thing generated or made, whether by nature or art, is generated or made out of something else; and this something else is called its subject or matter. Such is iron to the saw; such is timber to the boat. Now this *subject* or *matter* of a thing being *necessarily previous* to that thing's existence, is *necessarily different* from it, and *not the same*. Thus iron, as iron, is not a saw; and timber, as timber, is not a boat. Hence, then, one character of every *subject* or *matter*, that is, the character or *negation* or *privation*. [He means *negation* or privation of what is to be made out of it].

142 which is described as destitute of every attribute or quality,

"Again, Though the *subject* or *matter* of a thing be not that thing, *yet*, were it incapable of becoming so, it could not be called its subject or matter. Thus iron is the *subject* or *matter* of a saw; because, though *not* a saw, it may still *become* a saw. On the contrary, timber is *not* the subject or matter of a saw; because it not only (as timber) is no saw, but can never be made one from its very nature and properties. Hence, then, besides *privation*, another character of every *subject* or *matter*, and that is the character of *aptitude* or *capacity*. [He means aptitude or capacity to be that which is made out of it].

"Again, When one thing is the *subject* or *matter* of *many* things, it implies a *privation* of them all, and a *capacity* to them *all*. Thus iron being the subject or matter of the saw, the axe, and the chissel, implies *privation* and *capacity* with respect to *all three*. Again, We can change a saw into a chissel, but not into a boat; we can change a boat into a box, but not into a saw. The reason is, there can be no change or mutation of one thing into another where the two changing beings do not participate the same matter (D). But even here, were the boat to moulder and turn to earth,

(D) In a note he says: This reasoning has reference to what the ancients called υλη προσεχης, *the immediate matter*, in opposition to υλη, πρωτη, *the remote* or *primary matter*.

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earth, and that earth by natural process to metallize and become iron; through such progression as this we might suppose even the boat to become a saw. Hence therefore it is, that *all change* is by immediate or mediate participation of the *same matter*. Having advanced thus far, we must be careful to remember, first, that every *subject* or *matter* implies, as such, *privation* and *capacity*; and next, that *all change* or *mutation* of beings into one another is *by means of their participating the same common matter*. This we have chosen to illustrate from works of art, as falling more easily under human cognizance and observation. It is, however, no less certain as to the productions of nature, though the superior subtlety in these renders examples more difficult. The question then is, whether in the world which we inhabit, it be not admitted from experience, as well as from the confession of all philosophers, that substances of every kind (E), whether natural or artificial, either immediately or mediately, pass into one another: and whether, in that case, there must not be some one *primary matter* common to *all things*. I say some *one primary matter*, and that common to *all things*, since without some *such* matter, *such mutation* would be wholly impossible. But if there be some *one primary matter*, and that *common to all things*, this *matter* must imply, not (as particular and subordinate matters do) a *particular* privation and a *particular* capacity, but, on the contrary, *universal* privation and *universal* capacity. If the notion of such a being appear strange and incomprehensible, we may farther prove the *necessity* of its existence from the following considerations: Either there is no such general change as here spoken of; which is contrary to fact, and would destroy the sympathy and congeniality of things: Or, if there be, there must be a matter of the character *here* established; because without it (as we have said) such change would be *impossible*. Add to this, however hard *universal* privation may appear, yet had the *primary matter*, in its proper nature, any one particular attribute, so as to prevent its *privation* from being unlimited and universal, such *attribute would run through all things*, and be conspicuous in all. If it were white, all things would be white; if circular, they would be circular; and so as to other attributes; which is contrary to fact. Add to this, that the *opposite* to such attribute could *never* have existence, unless it were possible for the same thing to be at *once* and in the same instance both white and black, circular and rectilineal, &c. since this inseparable attribute would necessarily be *every where*; because the *matter*, which implies it, is itself *every where*, at least may be found in all things that are generated and perishable.

143 o be hend- ly by ction nalo-

"Here then we have an idea (such as it is) of that singular being υλη πρωτη, the *primary matter*; a being which those philosophers who are immerged in sensible objects know not well how to admit, though they cannot well do without it; a being which flies the perception of every *sense*, and which is at best, even to the *intellect*, but a negative object, no otherwise *comprehensible* than either by *analogy* or *abstraction*. We gain a glimpse of it by *abstraction*, when we say that the *first matter* is *not* the lineaments and complexion which make the beautiful face, *nor yet* the *flesh* and *blood* which make those lineaments and that complexion; *nor yet* the liquid and solid aliments which make that flesh and blood; *nor yet* the simple bodies of earth and water which make those various aliments; but *something*, which being *below* all these, and supporting them all, is yet *different* from them all, and essential to their existence. We obtain a sight of it by *analogy*, when we say, that as is the brass to the statue, the marble to the pillar, the timber to the ship, or any one *secondary matter* to any one *peculiar form*; so is the *first* and *original matter* to all *forms in general*."

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Such is the doctrine of the Peripatetics concerning the *primary matter* or the basis of bodily substances. We forbear to make any remarks upon it till we have seen what they say of *form*, the other essential part of every body; for what is meant by *matter* and *form* will be most completely seen when they are viewed together.

"FORM (says the same elegant writer) *is that elementary constituent in every composite substance, by which it is* DISTINGUISHED, CHARACTERIZED, *and known, from every other*. But to be more explicit: The *first* and most simple of all *extensions* is a *line*: this, when it exists, united with a *second* extension, makes a *superficies*; and these two existing together with a *third*, make a *solid*. Now this *last* and *complete* EXTENSION we call the *first* and *simplest* FORM; and when this *first* and *simplest form* accedes to the *first* and *simplest matter*, the union of the two produces *body*; which is for that reason defined to be *matter triply extended*. And thus we behold the rise of *pure* and original *body* (F). It must be remembered, however, that *body*, under this character, is something *indefinite and vague*, and scarcely to be made an *object* of *scientific contemplation*. It is necessary to this end that its extension should be *bounded*; for as yet we have treated it without such regard. Now, the *bound* or *limit* of *simple body* is *figure*; and thus it is that *figure*, with regard to *body*, becomes the next *form* after *extension*. 144 The Peripatetic doctrine concerning form.

"But though the *boundary* of body by *figure* is one step towards rendering it *definite* and *knowable*, yet is not this sufficient for the purposes of nature. It is necessary *here*, that not only its *external* should be duly bounded, but that a suitable regard should likewise be had to its *internal*. This *internal adjustment*, disposition, or *arrangement* (denominate it as you please), is called ORGANIZATION, and may be considered as the *third* form which appertains to body. By its accession we behold the rise of BODY PHYSICAL or NATURAL; for every such body is some way or other *organized*. And thus may we affirm, that these *three*, that is to say, *extension*, 145 The three original forms which, added to matter, constitute body physical.

(E) He must mean only bodily substances; for it is not admitted by such philosophers as make a distinction between mind and body, that the one ever passes into the other.

(F) "Original body (he says), when we look *downward*, has reference to the *primary matter*, its substratum: when we look *upwards*, it becomes itself a *matter* to *other things*; to the *elements*, as commonly called, air, earth, water, &c. and in consequence to all the variety of *natural productions*."

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extension, *figure*, and *organization*, are the *three original forms* to *body physical* or *natural*; *figure* having respect to its *external*, *organization* to its *internal*, and *extension* being common both to one and to the other. It is more than probable, that from the variation in these *universal* and (as I may say) *primary forms*, arise most of those *secondary* forms usually called *quantities sensible*, because they are the proper objects of our several sensations. Such are roughness and smoothness, hardness and softness; the tribes of colours, savours, odours; not to mention those powers of character more *subtle*, the powers electric, magnetic (G), medicinal, &c.

"Here therefore we may answer the question, how *natural* bodies are *distinguished*. Not a single one among them consists of *materials in chaos*, but of materials wrought up after the most exquisite manner, and that conspicuous in their *organization*, or in their *figure*, or in *both*.—As therefore every *natural body* is distinguished by the *differences* just described, and as these *differences* have nothing to do with the *original matter*, which being everywhere similar can afford no distinction at all; may we not here infer the expediency of ESSENTIAL FORMS, that every *natural substance* may be essentially *characterized*? These *forms*, though they differ from matter, can yet *never subsist without it*; but *united* with it, they help to produce every *composite* being, that is to say, in other words, every *natural substance*, in the visible world. It must be remembered, however, that it is the FORM in this union which is the *source of all distinction*. It is by *this* that the *ox* is distinguished from the *horse*, not by that grass on which they subsist, the *common matter* to both. To which also may be added, that as figures and sensible qualities are *the only objects of our sensations*, and these are all *parts* of *natural form*; so therefore (contrary to the sentiment of the vulgar, who dream of nothing but of matter) *it is form, which is in truth the whole that we either hear, see, or feel*; nor is *mere matter* any thing better than an *obscure imperfect being*, knowable only to the *reasoning faculty* by the two methods already explained, I mean that of *analogy* and that of *abstraction*. Here therefore we conclude with respect to *sensible forms*, that is to say, *forms immerged in matter* and *ever inseparable* from it. In *these* and *matter* we place the ELEMENTS OF NATURAL SUBSTANCE."

If this extract appear long, let it be remembered that it contains the fullest and most perspicuous detail which is to be found in the English language, of a doctrine of which the author of *Ancient Metaphysics* supposes Locke to have been ignorant; and for which ignorance he affects to treat the English philosopher with supercilious contempt. Had Locke really been ignorant of the ancient doctrine of *matter* and *form*, it is probable that most people will be of opinion, that the *contempt* expressed by his censurer might have been spared; but if it should appear, that, as far as this theory is intelligible, it differs not, except in words, from the doctrine laid down in the *Essay concerning Human Understanding*, what shall we think of that zeal for ancient phrases, which had influence sufficient to make one respectable philosopher pour contempt upon another who was an ornament to his country?

146 Matter cannot be destitute of solidity.

What Mr Harris has said of *matter* and *form* respecting works of art, is sufficiently intelligible, and extremely just. Nor should we object to the account which he gives of the origin of natural body, if he had not divested his first matter of every power and every quality, solidity and extension not excepted. But though we can suppose body divested of any one particular figure and of every sensible quality, such as colour, odour, tastes, &c. and the *substratum* or *basis* or *matter* of it still to remain, yet it seems impossible to conceive it divested of *solidity* without supposing it totally annihilated. Nay, if we have any just notion at all of solidity, it is evidently inseparable from the substratum of body, whatever that substratum be; and indeed though Mr Harris divests his first matter of every attribute, the argument by which he proves the necessary existence of such a being does not require its privation to be so universal. "Had the *primary matter* (says he), in its proper nature, any one particular attribute, so as to prevent its privation from being unlimited and universal, *such attribute would run through all things* and be conspicuous in all." This indeed is obvious and undeniable: but *solidity* and *extension* do in *fact* run through *all things* into which the *substratum* or *matter* of body is ever formed or ever can be conceived to be formed; and therefore there is no necessity for supposing the first matter divested of these attributes (H).

Mr Harris says, that both Timæus and Plato drop expressions

(G) That it is from the *extension*, *figure*, and *organization* of bodies, that their *medicinal* powers arise, seems to be undeniable; for medicines operate by contact: but it is not so clear that the same *forms*, to use the author's language, are the source of *magnetical* powers. If the magnet be surrounded with an atmosphere extending to a certain distance, such may be the case; but if not, the author's conjecture must be ill founded. See MAGNETISM.

(H) Nor does it appear that it was divested of them by all the ancient philosophers. We learn from Cudworth, that "the atomical physiology, the most ancient perhaps of any, teaches that body is nothing else but *διαστατον αντιτυπον*, *extended bulk*; and that nothing is to be attributed to it but what is included in the nature and idea of it, viz. greater or less magnitude, with divisibility into parts, figure, and position, together with motion or rest, but so as that no part of body can ever move itself. And consequently, this philosopher supposes, that there is no need of any thing else besides the simple elements of magnitude, figure, site, and motion, (which are all clearly intelligible, or different modes of extended substance), to solve the corporeal phenomena by; and therefore not of any substantial *forms* distinct from the matter; nor of any other qualities really existing in the bodies without, besides the results or aggregates of those simple elements, and the disposition of the insensible parts of bodies in respect of figure, site, and motion; nor of any intentional *species* or *shows* propagated from the objects to our senses: nor, lastly, of any other kind of motion or action really distinct from

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expressions as if they considered *matter* to be *place;* but place, as will be seen afterwards, can be the basis of nothing. He likewise quotes a passage from Ammonius on the predicaments, in which it is said "that there never was in *actuality* either matter without body, or body without quality;" and we appeal to our readers if it be not absolutely impossible to contemplate such a being even in *idea*. To the question, Whether the first matter has a separate existence by itself, distinct from all the qualities of body, the author of *Ancient Metaphysics* answers thus:—"We have no idea of it existing separately, because we find no such a thing in nature, from which we draw all our ideas; but whether there may not be such a thing existing in the regions of infinite space, as *matter* without *form* and *dimensions;* is what I think no man can take upon him to decide." But with all submission, if a man cannot decide this question with the utmost certainty, his three ponderous volumes are nothing better than useless paper: for the subject of them is things *existing;* and concerning existence we know nothing with greater certainty, than that a being of which nothing positive can be affirmed, cannot possibly have any existence.

147 Some first matter common to all bodies; That, in the world which we inhabit, bodily substances of every kind, whether natural or artificial, either immediately or mediately pass into one another, is a truth which cannot be denied: and therefore it follows, that there must be some one primary matter common to all things. In modern philosophy this primary matter is considered as solid, and as the *substratum* of all bodies; and all those things which, in the language of Mr Harris, are comprehended under the appellation of *form* are called *qualities:* so that on this subject the ancient and modern philosophy differ in nothing but in the latter using the word *qualities* instead of the word *form;* and defining the first matter to be, a *solid* substance every where the same," whilst the ancient philosophy considers it as void of solidity.

148 Of the nature of which, all men are equally ignorant. Of the nature of this first matter all philosophers are equally ignorant: for, as Mr Harris says, it is in truth *form;* or, as modern philosophers would say, they are in truth *qualities*, which are the whole that we either hear, or see or feel, or of which we have either idea or conception. Mr Locke says expressly, "that if any one will examine himself concerning his notion of pure substance in general, he will find that he has no other idea of it at all, but only a supposition of he knows not what support of such qualities as are capable of producing simple ideas in us."

149 How we know that the things immediately perceived are qualities. But how, it has been asked, do we know that the things which we perceive are qualities, and cannot exist without a subject? We answer, Because every one of them, except solidity, may be changed or destroyed, and the subject in which they inhere still remain. Thus, though wax may be melted or burnt, and be no longer a hard red substance of such a figure and such a smell, the matter which supported the hardness, figure, colour, and smell, still remains; for melted wax or ashes is as much a solid substance as is that which may be used for the sealing of letters, &c.

It has been said that solidity (1) is the *substratum* of body;

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from local motion (such as generation and alteration), they being neither intelligible as modes of extended substance, nor any way necessary: Forasmuch as the forms and qualities of bodies may well be conceived to be nothing but the result of those simple elements of magnitude, figure, site, and motion, variously compounded together; in the same manner as syllables and words in great variety result from the different combinations and conjunctions of a few letters, or the simple elements of speech; and the corporeal parts of sensation, and particularly that of vision, may be solved only by local motion of bodies, that is, either by corporeal effluvia (called *simulacra*, *membranæ*, and *exuviæ*), streaming continually from the surface of the objects, or rather, as the later and more refined atomists conceived, by pressure made from the object to the eye, by means of light in the medium. So that ως δια βακτηριας του ταθεντος αερος το βλεπομενον αναγγελλεται, the sense taking cognizance of the object by the subtle interposed medium, that is tense and stretched (thrusting every way from it upon the optic nerves), doth by that, as it were by a staff, touch it. Again, Generation and corruption may be sufficiently explained by concretion and secretion, or local motion, without substantial forms and qualities. And lastly, Those sensible ideas of light and colours, heat and cold, sweet and bitter, as they are distinct things from the figure, site, and motion of the insensible parts of bodies, seem plainly to be nothing else but our own fancies, passions, and sensation, however they be vulgarly mistaken for qualities in the bodies without us. *Cudworth's Intellectual System*, Book i. chap. 1.

This, as will be seen by and by, is the philosophy of Newton, Locke, and all their followers: and that it is the genuine philosophy of the ancient atomists, we may safely take the word of the author whom we have quoted; for no modern has been more conversant with their writings, more completely master of their language, or has given their sense with greater accuracy. Those authors, therefore, who in their zeal for ancient metaphysics would explode the physiology of Newton and Locke, and substitute in its place the Aristotelian doctrine of *matter* and *form*, belie their own pretences; for the theory which they would banish is more ancient than that which they introduce, and we appeal to our readers if it be not more intelligible.

(1) The philosophers of most eminence who have maintained this opinion are, *Dr Watts;* the author of the *Procedure, Extent, and Limits, of the Human Understanding;* and *Dr Law*, late bishop of Carlisle, who in a note upon *King's Origin of Evil* gives the opinion of the triumvirate in the following words:—"We find by experience, that a thing will always exhibit the same appearances in some respects, though it admit of changes in others: or, in Mr Locke's language, that certain numbers of simple ideas go constantly together, whereas some others do not. The former of these we call the *substance*, thing, or being, itself; the latter are termed its modes or *accidents*. Thus the substance of *body*, as far as we know of it, consists in solidity and extension; which being necessarily finite, it also becomes capable of division, figure, and motion. These are its original inseparable qualities,

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body; and men have been probably led into this notion from a conviction that such *substratum*, whatever it be, is and must be solid; but that solidity is only a quality inseparable from the first matter, and not that matter itself, must be evident from this consideration, that solidity is the same in all bodies, and incapable of producing by itself any other effect than that of excluding from the place occupied by it every other solid substance. It could not of itself be the *substratum* of colour, taste, or smell, otherwise all bodies would be coloured, sapid, and odorous; and as, according to all our notions of it, it is incapable of any change, it could not by itself be so modified as to excite in us these sensations.

150 Our notion of matter relative and obscure.

The things then immediately perceived by us, or of which we have any adequate idea or conception, are only qualities which must belong to a subject; and all that we know about this subject is, that it is that to which such qualities belong. From this it is evident, that our notion of matter, as distinguished from its qualities, is a relative * and obscure notion, and must remain obscure till men have other faculties. In this the philosopher seems to have no advantage above the vulgar: for as they perceive colour, and figure, and motion, by their senses, as well as he does; and as both are equally certain that there is a subject of those qualities; so the notions which both have of this subject are equally obscure: or, to speak more properly, they have no *positive* notion of it at all. When a philosopher calls it the *first matter*, a *substratum*, or a *subject of inhesion*, those learned words convey no meaning but what every man understands and expresses, by saying in common language, that it is a thing extended, solid, and moveable.

* *Reid's Essays on the Intellectual Powers of Man.*

They are therefore *qualities*, or, in the language of ancient philosophy, *forms* alone, about which, in corporeal substance, we can reason with precision and certainty; and it is sufficient for all the purposes of life that we have of them an adequate knowledge. For as the *first matter* or original *substratum* of all bodies seems to be the same, though we know not what it is; and as one body is distinguished from another only by its *qualities* or *powers;* a knowledge of the nature of these is all that can be necessary to direct our conduct with respect to the various objects with which we are surrounded.

151 Qualities primary and

Qualities thus considered in bodies, are, first, such as are utterly inseparable from the body, in what state soever it is; such as in all the changes and alterations which it suffers, and under all the force which can be employed upon it, it constantly keeps. Thus, in the instance already given, a stick of sealing wax may, by the operations of fire, be rendered liquid or reduced to smoke and ashes; and when it has undergone these changes, it has lost many of the sensible qualities which it had when a long round substance fit for the purpose of sealing letters; but other qualities which were then perceivable in it still remain: for not only liquid wax, but every particle of smoke and ashes, is solid and extended, as well as the hardest or largest body; and every such particle has likewise some figure, and is capable of motion or rest. Again, If a grain of wheat or any other corporeal substance, be divided into two parts, and each part be again divided without end, still the smallest particle of it will be solid, extended, of some figure, and capable of further division. *Solidity, extension, divisibility*, and *motion* or *rest*, are therefore qualities inseparable from *body*, and have on that account been with great propriety called its *original* or *primary qualities.*

152 secondary

There are other qualities, which in truth are nothing in the bodies themselves, but powers arising from the magnitude, figure, texture, and motion, of their insensible parts to produce in us various sensations; such are *colours, sounds, tastes*, and *odours*. These have been denominated *secondary qualities;* and to them may be added

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lities, which constitute the thing, and seem not to depend on any thing else as a *subject*. But a particular figure, motion, &c. are only accidents or modes of its existence; which do not necessarily attend it, though they themselves cannot be supposed to exist without it. The substance of *spirit* consists in the powers of thinking and acting, which likewise admit of various modifications. This seems to be all that we can learn concerning the nature of things from observation and experience. To inquire into the *manner* how these, which we call *properties*, exist together, or to attempt to explain the *cause*, ground, or reason, of their union, is in vain. To assign the word *substance* for a representation of it, is saying nothing: it is setting a mere word for what we have neither any idea of nor occasion for. Indeed if we consider these primary qualities as needing something to inhere in, we are obliged to seek for something to support them: and by the same way of reasoning, we may seek for something else to support that other something, and so on; and at last shall find no other support for the whole but the cause which produced it." "Dr Watts (continues the Bishop) is of opinion, that it is introducing a needless *scholastic* notion into the real nature of things, and then fancying it to have a real existence:" (*Logic*, p. 14.). The author of the *Procedure, Extent*, &c. affirms, "That as far as we directly know the essential properties of any substance, so far we have a *direct* knowledge of the substance *itself:* and if we had a direct knowledge of *all* the essential properties of any substance, we should have an *adequate* knowledge of that substance; for surely, if there be any meaning in words, the knowing any thing of the essential properties of a thing is knowing *so much* of its very substance."

That the substance of body consists in *solidity* and *extension*, and nothing more; and that these depend not upon any thing else as a *subject;* cannot be true: for *solidity*, in our conception, is nothing but *impenetrability;* but whoever uses the word *impenetrability*, certainly means that there is *something* impenetrable. That there is some real thing or being different from solidity and extension, which impresses us with the notion that it is solid and extended, is self-evident to all mankind: if it be not matter, these conceptions must be communicated to us by the immediate agency of the Deity, which seems to have been the real opinion of the Bishop of Carlisle. But this differs not from the theory of Berkeley, which we shall consider by and by.

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added a third sort, which are universally allowed to be barely *powers*, though they are in fact as much real qualities in the subject as those we have just mentioned. Thus the power in fire to produce by its primary qualities a new colour or consistency in wax or clay, is as much a quality in the fire as the power which it has to produce in us a new sensation of warmth or burning. That *colours*, *tastes*, *sounds*, and *odours*, as they are perceived by us, are mere sensations, has been already proved: and that the powers in the bodies which produce these sensations are not, like *solidity* and *extension*, inseparable from the body to which they may belong, is evident; because a piece of *red* wax may be reduced to *black* ashes; and because by pounding an almond we may change its clear white colour into a dirty hue, and its pleasant taste into one that is oily and rancid; and a single rent through the body of a bell destroys its sound.

The primary qualities of body have a real existence independent of us and of every other creature. Thus the particular *bulk*, *number*, *figure*, and *motion*, of the *parts* of *fire* or *snow* are *really in the fire or snow*, whether any man's senses perceive them or not; and therefore these may be called *real qualities*, because they really exist in the bodies: But *light*, *heat*, *whiteness*, or *cold* (as they are perceived by us), are no more *really in fire or snow*, than sickness is in *tartar* or pain in a *sword*. Take away the sensations of them: let not the eyes see light or colours, nor the ears hear sounds; let not the palate taste nor the nose smell; and all colours, tastes, odours, and sounds, as they are such particular sensations, vanish and cease, and are reduced to their causes, *i. e.* to the bulk, figure, and motion of the parts of the body.

Bodily qualities are of three sorts.

The qualities then that are in bodies, rightly considered, are of three sorts. 1. The *bulk*, *figure*, *number*, *situation*, and *motion* or *rest*, of their *solid* parts. Of these, as they are in themselves, we have clear and distinct notions. We know that they are in the body whether we perceive them or not, and we call them *primary* or *essential qualities*. 2. The power that is in any body, by reason of its internal texture and insensible primary qualities, to operate upon our senses in a peculiar manner, producing in us the different sensations of *colours*, *sounds*, *tastes*, or *smells*, &c. These we have called *secondary qualities*, but they are often termed *sensible qualities*. 3. The *power*, that is in any body, by reason of the particular constitution of its primary qualities, to make such a *change* in the *bulk*, *figure*, *texture*, and *motion* of *another body*, as to make it operate on our senses differently from what it did before. Thus, the sun has a power to make wax white, and fire to make lead fluid. These are universally called *powers*; but we have no such notions of them as we have of the *primary qualities* of bodies. We know that they exist, but we know not what they are. It has indeed been discovered, that the sensation of smell is occasioned by the effluvia of bodies *; that of sound by their vibration. The disposition of bodies to reflect a particular kind of light occasions the sensation of colour; and the operation of the minute parts of bodies upon the nerves of the tongue and palate is the cause of tastes. Very curious discoveries have been made of the nature of heat and its manner of operating, and an ample field still remains. We are likewise intuitively certain, that body can operate upon body only by impulse; but how certain impulses upon certain organs should produce sensations in us to which there is nothing similar in the impelling body, is equally unknown to the clown and the philosopher.

* *Reid's Essays on the Intellectual Powers of Man*, and *Locke's Essay*, &c.

154
The doctrine of the ancient atomists respecting qualities.

Such is the distinction which in modern philosophy is made between primary and secondary qualities; but it is a distinction which was likewise well known to that sect of ancient philosophers who were denominated *atomists*. At the head of these were Thales and Pythagoras (K); and we may infer from Aristotle, that the sect comprehended almost all the physiologists who taught before himself and Plato: for he says †, Δημοκριτος και οἱ πλειστοι των φυσιολογων ατοπωτατον τι ποιουσι, παντα γαρ τα αισθητα απτα ποιουσι, και εις σχηματα αναγουσι τους χυμους: "Democritus, and *most* of the *physiologists*, fall into a great absurdity; for they make all sense to be touch, and resolve sensible qualities into the figures of insensible atoms." And he adds, that "the former physiologists (without exception) said not well, that there is no black and white without the sight, nor bitter and sweet without the taste." He elsewhere ‡ tells us, that those philosophers explained generation and alteration without forms and qualities, by figures and local motion." Δημοκριτος και Λευκιππος ποιησαντες τα σχηματα την αλλοιωσιν και την γενεσιν εκ τουτων ποιουσι διακρισει μεν και συγκρισει γενεσιν και φθοραν ταξει δε και θεσει αλλοιωσιν. "Democritus and Leucippus having made figures (or variously figured atoms) the first principles, make generation and alteration out of these; namely, generation

† *Lib. de Sensu et Sensibili*, cap. 4.

‡ *De Generatione et Corruptione*, lib. i. cap. 2.

(K) This is denied by Bishop Warburton, who thinks nothing better settled than that Democritus and Leucippus were the authors of the atomic physiology. We highly respect the learning and ingenuity displayed in the Divine Legation of Moses; but on this point we are convinced that its author is mistaken. Strabo expressly affirms, that Moschus the Phœnician was the author of the atomic physiology; and Cudworth has proved, by arguments which to us are perfectly satisfactory, that Thales and Pythagoras were both atomists, and that they derived the doctrine from Phœnicia or Egypt. They did not, indeed, speculate in physics, but delivered their doctrines as they had received them from tradition, and they referred all motion to mind as its cause. Leucippus and Democritus, we believe were the first speculative atomists: but though they refined upon, and perhaps improved, the more mechanical part of the physiology of their masters, they unhappily dropt the better part of it; and, banishing mind from their system of the universe, they became materialists and atheists. With the sober and pious part of philosophers this brought the atomic theory into disrepute; and Plato and Aristotle, who were theists, when they opposed that theory, always pointed their arguments against Leucippus and Democritus, which is probably what led the learned Bishop to consider these atheists as the authors of the atomic physiology.

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tion together with corruption from the concretion and secretion of them, but alteration from the change of their order and position." By the atomic physiologists the name of *quality* was generally applied only to those things which we have called *secondary qualities*. The *primary* being considered as *essential* to *matter*, were seldom, if ever, called *qualities*. That the atoms, which they held to be the first principles of bodies, were figured, solid, extended, and moveable, is apparent not only from the short view of their system which we have given from Cudworth, but likewise from the passages which we have just quoted from Aristotle: but the question debated between them and their antagonists was, whether those atoms had *smell*, *taste*, and *colour*; or, as it was commonly expressed, whether they had *qualities*? Democritus, Leucippus, and the other atomists, we see, maintained that they had not; and the following account of the doctrine of Protagoras, another philosopher of that school, shows, that on this subject at least the ancient advocates for the atomic system reasoned as justly as any of the moderns, and much more justly than the Peripatetics and Platonists by whom they were opposed. Plato having in his Theœtetus first said in general that the philosophy of Protagoras made all things to consist of a commixture of atoms and local motion, represents his doctrine concerning colours in particular, after this manner: "First, As to that which belongs to the sight, you must conceive what is called a white or black colour, not to be any thing absolutely existing either without your eyes or within your eyes; but black and white, and every other colour, is caused by different motions made upon the eye, from objects differently modified; so that it is nothing either in the agent or patient absolutely, but something which arises from between them both (L)." From this passage it is plain, that Protagoras thought of colours exactly as Mr Locke thought, that they are not *real qualities* existing in bodies, but merely sensations excited in our minds; and indeed he is presently after represented as having called them τινα εν ημιν φασματα, *certain fancies* or *appearances in us*. But there is in the Theœtetus another passage, in which a fuller account is given of the atomic philosophy, to this purpose: "The principle upon which all these things depend is this, That the whole universe (M) is motion of atoms and nothing else: which motion is considered two ways, and is accordingly called by two names, *action* and *passion*. From the mutual congress, and, as it were, attrition of these together, are begotten innumerable offsprings, which though infinite in number, yet may be reduced to two general heads, *sensibles* and *sensations*, which are both generated at the same time. The *sensations* are *seeing*, *hearing*, and the like; and the corresponding *sensibles* are *colours*, *sounds*, &c. Wherefore, when the eye and its proper object meet together, both the αισθητον and the αισθησις, the *sensible idea* of white and black, and the *sensation* of seeing, are generated together, neither of which would have been produced if those two had not met. The like is to be conceived of all other *sensibles*, as hot and cold, &c. None of these are absolute things in themselves, or real qualities in external objects; but they are begotten from the mutual congress of agent and patient, and that by motion. So that neither the agent has any such thing in it before its congress with the patient, nor the patient before its congress with the agent. But the agent and patient meeting together, and begetting *sensation* and *sensibles*, both the object and the sentient are forthwith made to be so and so qualified; as when honey is tasted, the sensation of tasting, and the quality of sweetness are begotten together, though the sensation be vulgarly attributed to the taster, and the quality of sweetness to the honey." The conclusion of all which is summed up thus, ουδ εν ειναι αυτο καθ'αυτο, αλλα τινι αιει γιγνεσθαι: "Not one of these sensible things is anything absolutely in the object without, but they are all generated or made relative to the sentient (N)."

The language of ancient philosophy was defective in precision; terms were used vaguely and improperly, so that the meaning of the author is often to be collected only from the context. When Protagoras is here made to say, that when the agent and patient meet together, both the object and the sentient are forthwith made to be so and so *qualified*; as when honey is tasted, the sensation of tasting and the *quality* of sweetness are begotten together; it could not be his meaning, that any real change is made upon the external object merely by our tasting it, but only that the actual sensation and the sensible *idea* of sweetness are produced at once; just as he had said before, that the sensible idea of white or black, and the sensation of seeing, are generated together. If his words be thus interpreted they express a noble truth; and the whole passage shows, that the ancient atomic theory differed not from the theory of Des Cartes, Newton, and Locke, being the most rational, as well as the earliest system of physics with which we have any acquaintance. By divesting body of *essential forms* distinct from matter and motion, and by giving to the first matter extension and solidity, it renders the corporeal world intelligible; and accounts for those appearances

(L) Υπολαβε τοινυν ουτωσι κατα τα ομματα πρωτον, ὁ δε καλεις χρωμα λευκον μη ειναι αυτο ἑτερον τι εξω των σων ομματων, μηδ' εν τοις ομμασι, αλλα μελαν τε και λευκον και ὁτιουν αλλο χρωμα εκ της προσβολης των ομματων προς την προσηκουσαν φοραν φανειται γεγενημενον και ὁ δε εκαστον ειναι φαμεν χρωμα, ουτε το προσβαλλον ουτε το προσβαλλομενον αλλα μεταξυ τι εκαστω ιδιον γεγονος.

(M) Protagoras was a follower of Leucippus and Democritus in every thing, and of course an atheist.—This, however, does not hinder him from having been a correct physiologist with respect to the composition of body; and as such only is he quoted by us. It is, indeed, melancholy to think, that there was hardly a sect of ancient philosophers in which there were not many atheists.

(N) Αρχη δε εξ, ἡς α νυν δη ελεγομεν παντα ηρτηται ἡ δε αυτων, ὡς το παν κινησις ην και αλλο παρα τουτο ουδεν, της δε κινησεως δυο ειδη, πληθει μεν απειρον, ἑκατερον, δυναμιν δε το μεν ποιειν εχον, το δε πασχειν, &c.—See the *Theœtetus*; see also *Cudworth's Intellectual System*, book i. chap. 1.

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pearances which are called secondary qualities, in a manner perfectly satisfactory. Aristotle indeed opposed the atomic philosophy, and had influence enough to bring it into disrepute for many ages; but when he insisted that the two constituent principles of body are *matter* and *form*, both independent of all sentient beings, and which may be conceived as existing distinct from each other, he substituted for a simple and sublime theory an absurd and incomprehensible fiction.

Chap. II. *Of the* Essences *of* Bodies.

155 essen- of bodies lt,

Having treated of the substance, qualities, and powers of body, we may seem to have exhausted this part of our subject; but there is still more to be done. Metaphysicians, ancient and modern, have introduced another term into the science, to denote that which distinguishes one species or sort of bodies from all other species or sorts; and this term we shall briefly explain. Gold is apparently different from lead, and from every other species of metal; a horse is apparently different from an ox, and from every other species of animals; and all animals apparently differ from all vegetables, as vegetables differ from metals.

156 ording ie Peri- tics and onists, essen- forms;

It is only with the *bodies*, not the minds of animals, that we are at present concerned: and we have seen that all bodies are composed of the same matter.—What then is it that makes different bodies exhibit to us such different appearances; or, in other words, how come they to be possessed of such different qualities and powers? It is (say the followers of Plato and Aristotle) from their having different *essential forms*, by which every natural substance is essentially characterized; for of every animal, vegetable, or metal, &c. there is a *form* conceived, as existing before the individuals in which it is incorporated, from which result all the properties of that animal, vegetable, or metal, such as *figure*, *size*, *colour*, and the other qualities perceptible by our senses: but this *internal and essential form* itself, from which all other forms result, is not perceptible by our senses, nor even by our understanding directly and immediately, nor otherwise than by the analogy formerly mentioned. These essential forms, we are told, mean something, which, though different from matter, can yet never subsist without it; something which, united with it, helps to produce every *composite* being, that is to say, in other words, every natural substance in the visible world.

157 hese s have xist-

This assertion Mr Harris submits with deference to his contemporaries; because (says he) "I speak perhaps of spectres as shocking to some philosophers as those were to Æneas which he met in his way to hell—*Terribiles visu formæ*." The elegant author's unwillingness to frighten his contemporaries, was a proof of his amiable and benevolent disposition; but he needed not to have suffered from any such apprehension. Those spectres, apparently so dreadful, had long before been laid to rest by the incomparable Cudworth, who has demonstrated, that *essential forms* different from matter and motion, as they have no real existence, had no place in the most ancient philosophy; and that the different appearances or sensible qualities which different bodies exhibit, are the result of the different contexture of their insensible parts. Thus, gold and lead are composed of the same primary matter, but the atoms or minute parts of that matter are in the one substance differently combined from what they are in the other; and this different combination is the sole cause that gold is specifically heavier than lead, more ductile, and of a different colour, &c. For the very same reason, iron is harder than either gold or lead, specifically lighter, and possessed of many other sensible qualities which are not found in either of these substances. One vegetable differs from another externally in size, colour, taste, smell, rapidity of growth, and proportion of parts, &c.: but all vegetables are composed of the same matter; and the external difference which prevails among them is the result of a different structure and motion of their insensible parts. The same is to be said of the differences which prevail among the bodies of animals; they all result from internal organization and motion, and from nothing else, whatever be the immediate cause of that motion.

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157 The real essences of bodies unknown to us.

This particular internal texture and motion of insensible parts, is that which makes one sort of bodies differ externally from every other sort of bodies; and it is by modern metaphysicians called the *real essence* of bodies. Thus, that internal texture of minute parts, which makes gold of a bright yellow, extremely ductile, specifically heavier than all other metals, and soluble in *aqua regia*, is the real essence of gold; but what that essence is in itself no man can tell, as we perceive only the qualities which result from it. We are, however, certain, that it is different from the real essences of lead and iron, because it produces different effects from those which are produced by these essences; and different effects are never produced in the same circumstances by the same cause.

159 Nominal essences, what they are,

We have called the internal texture and motion of the insensible parts of bodies, their *real essences*, to distinguish them from other *essences* which are only *nominal*, and with which we are perfectly acquainted, because they are the fabrication of our own minds.—Thus, a beautiful bright yellow, a certain specific gravity, extreme ductility, and solubility in *aqua regia*, are the qualities by which we distinguish gold from all other metals. Of these qualities we frame a sort of general conception, which we call the *essence* of gold; and every substance in which we find this essence, we class under the specific name gold. For though it is obvious that our conceptions cannot be the *real essences* of things external, yet are they sufficient guides to these essences, as we know that bodies which, being all formed of the same matter, have the very same sensible qualities, must likewise have the same internal organization or texture of parts, because it is only in that organization or texture that one body can differ from another.—And so much for bodily substance, qualities, and essences.

Chap. III. *Of the* Existence *of* Matter.

160 Berkeley attempts to demonstrate that matter has no existence.

We have endeavoured to prove, that all corporeal substances consist of minute atoms, solid and extended; and that the sensible qualities of every body result from the combination and motion of the atoms of which that body is composed. The celebrated Berkeley, bishop of Cloyne,

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Cloyne, however, attempted to demonstrate that these atoms have no real existence; and that the very supposition of a solid, extended, and inert substance, being the archetype of our ideas, involves in it an absurdity and contradiction.

It is universally allowed, that all our knowledge of matter is derived through the senses, either immediately in the very act of sensation, or mediately by an association which is resolvable into a process of reasoning. According to the principles which we have stated and laboured to establish, matter itself is no immediate object of the senses; and as these are the principles upon which the bishop erected his demonstration, it will be incumbent upon us to consider his theory, because it has been represented as in the highest degree pernicious, and as leading to universal scepticism.

161 The view of his theory given by his antagonists.

The author of the *Essay on the Nature and Immutability of Truth*, represents Berkeley as teaching us, "that external objects (that is, the things which we take for external objects) are nothing but ideas in *our* minds; in other words, that they are in *every respect* different from what they appear to be; that matter exists not but in *our* minds; and that independent on *us* and *our* faculties, the earth, the sun, and the starry heavens, have no existence at all; that a lighted candle hath not *one* of *those qualities* which it *appears to have;* that it is not white nor luminous, nor round, nor divisible, nor extended; but that, for any thing we know, or can ever know to the contrary, it may be an Egyptian pyramid, the king of Prussia, a mad dog, the island of Madagascar, Saturn's ring, one of the Pleiades, or nothing at all." With respect to the consequences of this theory, he affirms, that "it is subversive of man's most important interests, as a moral, intelligent and percipient being; and not only so, but also, that if it were universally and seriously adopted, the dissolution of society, and the destruction of mankind, would necessarily ensue within the compass of a month."

The dissolution of society and the destruction of mankind are indeed dismal consequences—enough to make a man shudder in his closet. But do they really flow from Berkeley's system? They certainly do, if it be the aim of that system to prove that a candle has not any one quality which it appears to have, and that it may be a *mad dog;* for should all philosophers, by some means or other, become converts to the theory of Berkeley, as we know that the bishops Sherlock, Smalridge, and others, actually did, the dissolution of society and the destruction of mankind would indeed be inevitable. The scribbling race, by using mad dogs for candles, would all become infected with the hydrophobia; and having their natural irritability augmented by the canine rabies, they would bite and tear till not a human being were left alive.

162 A view of his theory given by himself.

But to drop this ludicrous style, so unsuitable to philosophical investigation and calm inquiry, we beg leave to affirm, that the theory of Berkeley is here totally and grossly misrepresented, and that not one of those dangerous consequences which flow from that misrepresentation can be fairly deduced from any thing taught in *The Principles of Human Knowledge* and the *Dialogues on the Existence of Matter*. So far is Berkeley from teaching that external things are nothing but ideas in *our* minds, and that they are in every respect different from what they appear to be, that he teaches the very reverse of this in the plainest language possible. "I am of a vulgar cast (says he), simple enough to believe my senses, and leave things as I find them. It is my opinion, that the real things are those very things I see and feel and perceive by my senses. That a thing should really be perceived by my senses, and at the same time not really exist, is to me a plain contradiction. When I deny sensible things an existence out of the mind, I do not mean *my* mind in particular, but *all* minds. Now it is plain they have an existence exterior to my mind, since I find them by experience to be independent of it. There is therefore some other mind wherein they exist during the intervals between the times of my perceiving them; as likewise they did before my birth, and would do after my annihilation. And as the same is true with regard to all other finite created spirits, it necessarily follows there is an *omnipotent eternal mind*, which knows and comprehends all things, and exhibits them to our view in such a manner, and according to such rules, as he himself hath ordained, and are by us termed the laws of nature."

So far is Berkeley from teaching that, independent on *us* and *our* faculties, the earth, the sun, and the starry heavens, have no existence at all, and that a lighted candle has not one of those qualities which it appears to have, that he over and over affirms the direct contrary; that the universe has a real existence in the mind of that infinite God, in whom, according to the scriptures, we all live, and move, and have our being; that a lighted candle has not only all those qualities which it appears to have, but that with respect to us, it has nothing else; that so far from being continually deceived by our senses, we are never deceived by them; and that all our mistakes concerning matter are the result of false inferences from true sensations.

The bishop makes the same distinction that we have made between ideas and notions; restraining the use of the former term to denote the relicks of sensation, and employing the latter to denote our knowledge or conception of spirits and all such objects as are not perceived by sense. He likewise affirms, that we can have no *idea* of an external inert substance; because an idea can be like nothing but another idea, or the sensation of which it is a relick: and as all mankind admit that ideas and sensations can have no existence but in the mind of a percipient being, he therefore infers that we can have no *idea* of any thing existing unperceived, and by consequence can have no idea of matter in the philosophical sense of that word. Solidity, extension, divisibility, motion, figure, colour, taste, and all those things which are usually called qualities primary and secondary, being according to him mere ideas, can have no existence but in a mind perceiving them; but so far is he from supposing their existence to depend upon the perception of our minds, that he says expressly, "When in broad day-light I open my eyes, it is not in my power to choose whether I shall see or no, or to determine what particular objects shall present themselves to my view; and so likewise as to the hearing and other senses, the ideas imprinted on them are not creatures of my will. There is therefore some other will or spirit that produces them.

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them. The question between the materialists and me is not, Whether things have a real existence out of the mind of *this* or *that* person? but, Whether they have an absolute existence, distinct from being perceived by *God*, and exterior to *all minds?* I assert, as well as they, that since we are affected from without, we must allow powers to be without in a being distinct from ourselves. So far we are agreed. But then we differ as to the kind of this powerful being. I will have it to be spirit; they matter, or I know not what third nature. Thus I prove it to be spirit: From the effects I see produced, I conclude there are actions; and because actions, volitions (for I have no notion of any action distinct from volition); and because there are volitions, there must be a will. Again, The things I perceive must have an existence, they or their archetypes, out of my mind: but being ideas, neither they nor their archetypes can exist otherwise than in an understanding: there is therefore an understanding. But will and understanding constitute in the strictest sense a mind or spirit. The powerful cause, therefore, of my ideas is, in strict propriety of speech, a spirit."

163 The theory however improbable, certainly possible,

163 This is a faithful abstract of Berkeley's theory given in his own words. Matter, according to him, cannot be the *pattern* or *archetype* of ideas, because an idea can resemble nothing but another idea, or the sensation of which it is a relick. Matter, he thinks, cannot be the *cause* of ideas; for every cause must be active, and matter is defined to be inert and incapable of action. He therefore infers, that all our sensations of what we call the qualities of body are the effect of the immediate agency of the Deity upon our minds; and that corporeal substance has no existence, or at least that we have no evidence of its existence. That such may *possibly* be the origin of our sensations, no man will deny who reflects upon the infinite power and wisdom of the Agent from whom they are said to proceed. Dr Reid himself, the ablest of all Dr Berkeley's opponents, frankly acknowledges that no man "can show, by any good argument, that all our sensations might not have been as they are, though no body or quality of body had ever existed."

164 Its consequences harmless.

164 In its consequences we do not perceive that this theory can be hurtful either to religion, to virtue, or to the business of common life; for it only explodes the notion of a substratum, which, though it may have a real existence, was never thought of by the generality of mankind in any nation under heaven. Dr Beattie indeed affirms, that in "less than a month after the non-existence of matter should be universally admitted, he is certain there could not, without a miracle, be one human creature alive on the face of the earth." But this assertion must be the consequence of his mistaking Berkeley's non-existence of matter for the non-existence of sensible objects, the reality and existence of which the bishop never denied. On the contrary, he expressly says, "We are sure that we really see, hear, feel; in a word, that we are affected with sensible impressions; and how are we concerned any farther? I *see* this cherry, I *feel* it, I *taste* it; and I am sure *nothing* cannot be seen, or felt, or tasted: it is therefore *real*. Take away the sensations of softness, moisture, redness, tartness, and you take away the cherry." All this is equally true and equally conceivable, whether the combined sensations which indicate to us the existence of the cherry be the effect of the immediate agency of God or of the impulse of matter upon our minds; and to the lives of men there is no greater danger in adopting the former than the latter opinion.

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165 A consequence of Berkeley's theory; which

165 But it has been said, that Berkeley's doctrine necessarily leads to scepticism in religion, as the same kind of reasoning which he employs to prove the non-existence of matter, operates equally against the existence of mind, and consequently against the possibility of a future state of rewards and punishments. "The rational issue of this system (we are told) is scepticism with regard to every thing excepting the existence of our ideas and their necessary relations. For ideas being the only objects of thought, and having no existence but when we are conscious of them, it necessarily follows, that there is no object of our thought which can have a continued and permanent existence. Body and spirit, cause and effect, time and space, to which we were wont to ascribe an existence independent of our thought, all are turned out of existence by this short dilemma: Either those things are ideas of sensation or reflection, or they are not: If they are ideas of sensation or reflection, they can have no existence, but when we are conscious of them: If they are not ideas of sensation or reflection, they are words without any meaning."

This sophism was advanced as a consequence from Berkeley's principles by Mr Hume; and upon these principles it has been deemed unanswerable by subsequent philosophers of great merit. But is it really a part of Berkeley's system, or can it be fairly inferred from the principles on which that system is built? These questions it is fit that Berkeley should answer for himself: and we shall venture to assert, that his answer will be perfectly satisfactory to every reader who attends to the distinction, which, after the bishop, we have stated between ideas and notions.

166 that author foresaw and

166 Though we believe this dangerous inference, from Berkeley's principles is commonly attributed to Hume as its author, it did not escape the sagacity of the bishop himself. In the third dialogue, *Hylas*, who pleads for the existence of matter, thus objects to the reasoning of his antagonist. "Notwithstanding all you have said, to me it seems, that according to your own way of thinking, and in consequence of your own principles, it should follow, that you are only a system of floating ideas, without any substance to support them. Words are not to be used without a meaning. And as there is no more meaning in spiritual substance than in material substance, the one is to be exploded as well as the other."

167 obviated, but

167 To this *Philonus* answers: "How often must I repeat, that I know or am *conscious* of my own being; and that I myself am not my ideas, but somewhat else; a thinking active principle, that perceives, knows, wills, and operates about ideas: I know that I, one and the same self, perceive both colours and sounds; that a colour cannot perceive a sound, nor a sound a colour; that I am therefore one independent principle, distinct from colour and sound; and, for the same reason, from all other sensible things and inert ideas. But I am not in like manner *conscious* either of the existence or essence of matter. Farther, I know what

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what I mean, when I affirm that there is a spiritual substance or support of ideas; i. e. that a spirit knows and perceives ideas. But I do not know what is meant, when it is said that an unperceiving substance hath inherent in it, and supports, either ideas or the archetypes of ideas. In the very notion or definition of material substance there is included a manifest repugnance and inconsistency. But this cannot be said of the notion of spirit. That ideas should exist in what doth not perceive, or be produced by what doth not act, is repugnant. But it is no repugnancy to say, that a perceiving thing should be the subject of ideas, or an active being the cause of them. That I, who am a spirit or thinking substance, exist, I know as certainly as I know that my ideas exist. I know likewise what I mean by the terms *I* and *myself*; and I know this immediately or intuitively; though I do not perceive it as I perceive a triangle, a colour, or a sound. Ideas are things inactive and perceived; and spirits a sort of beings altogether different from them, by which they are perceived. I do not, therefore, say, that my soul is an idea, or like an idea. However, taking the word *idea* in a large sense, my soul may be said to furnish me with an idea, that is, an image or likeness of God, though indeed extremely inadequate. For all the notion I have of God is obtained on reflecting on my own soul, heightening its powers, and removing its imperfections. I have, therefore, though not an inactive idea, yet in myself some sort of an active thinking image of the Deity. And though I perceive him not by sense, yet I have a notion of him, or know him, by reflection and reasoning. My own mind and my own ideas I have an immediate knowledge of; and by the help of these do immediately apprehend the *possibility* of the existence of other spirits and ideas. Farther, from my being, and from the dependency I find in myself and my ideas, I do by an act of reason *necessarily* infer the existence of a God, and of all created things in the mind of God. It is granted that we have neither an immediate evidence, nor a demonstrative knowledge, of the existence of *other finite spirits;* but it will not therefore follow, that such spirits are on a footing with material substances: if, to suppose the one be inconsistent, and if it be not inconsistent to suppose the other; if the one can be inferred by no argument, and there is a probability of the other; if we see signs and effects indicating distinct finite agents like ourselves, and see no sign nor symptom whatever that leads to a rational belief of matter. I say, lastly, that I have a *notion* of spirit, though I have not, strictly speaking, an *idea* of it. I do not perceive it as an idea, or by means of an idea; but know it by reflection. Whereas, I neither perceive matter objectively as I do an idea, nor know it as I do myself by a reflex act; neither do I mediately apprehend it by similitude of the one or the other, nor yet collect it by reasoning from that which I know immediately. All which makes the case of matter widely different from that of the Deity and all spirits.

Thus far we think Berkeley's theory tenible, and its consequences harmless. That by the immediate agency of the Deity all our sensations *might* be what they are, though matter had no existence, we think he has proved by arguments unanswerable; and we are likewise of opinion, that by admitting the evidence of sense, consciousness, and reason, in their fullest extent, and by distinguishing properly between those things of which we have *ideas* and those of which we have *notions*, he has sufficiently secured the existence of spirits or percipient beings, and obviated the irreligious sophistry of Hume before it was conceived by that author. But the good bishop stops not here. Not satisfied with proving that all our sensations lead us immediately to the Deity, and that, for aught we know, matter, as defined by philosophers, may have no separate existence, he proceeds farther, and endeavours to prove that matter cannot possibly exist. This appears even in the extracts which we have quoted from his book, in which he talks of the repugnance and inconsistency of the notion. In this part of his system, we think he errs greatly, and advances an opinion altogether inconsistent with his own just principles.

168 Not satisfied with this, he endeavours to prove that the existence of matter is impossible.

169 His reasoning

The repugnance of which he speaks, arises solely from considering solidity and extension as relicks of sensation, or ideas of the same kind with those of heat and cold, tastes and sounds. "Light and colours, heat and cold, extension and figures; in a word, the things we see and feel; what are they (says his lordship), but so many sensations, notions, ideas, or impressions, on sense? and is it possible to separate even in thought any of these from perception? Some there are who make a distinction betwixt *primary* and *secondary* qualities: by the former, they mean extension, figure, motion, rest, solidity or impenetrability, and number: by the latter, they denote all other sensible qualities, as colours, sounds, tastes, and so forth.—The ideas we have of these they acknowledge not to be the resemblances of any thing existing without the mind, or unperceived; but they will have our ideas of the primary qualities to be patterns or images of things which exist without the mind, in an unthinking substance which they call *matter*. But it is evident that extension, figure, and motion, are only ideas existing in the mind; that without extension solidity cannot be conceived; that an idea can be like nothing but another idea; and that consequently neither they nor their archetypes can exist in an unperceiving substance. Hence it is plain, that the very notion of what is called *matter* or *corporeal substance*, involves a contradiction in it."

170 fallacious.

This account of extension and solidity affords a striking instance how much the most vigorous and upright mind is liable to be warped by prejudice in behalf of a darling theory, and how apt the clearest understanding is to be blinded by the equivocal use of terms. That Bishop Berkeley possessed a vigorous and perspicacious mind, his most vehement antagonists are eager to admit; and that his intentions were good, is known to all Europe. Yet by the equivocal use of the word *idea*, which the writings of Locke had then introduced into the language of philosophy, he has here suffered himself to lose sight of a very proper and accurate distinction, which, so far as we know, was among the moderns first made by himself between *ideas* and *notions*. According to the bishop, "we have a *notion* of power and a *notion* of spirits, but we can have no *idea* either of the one or the other; for all ideas being passive

)f the xistence Matter.

passive and inert, they cannot represent unto us by way of image or likeness that which acts. Such is the nature of *spirit* or that which acts, that it cannot be of itself perceived, but only by the effects which it produceth. It must be owned, however, that we have some *notion* of soul, spirit, and the operations of the mind, such as willing, loving, hating, inasmuch as we know or understand the meaning of these words."

Now we beg leave to affirm, that what is here said of spirits, and of which we readily admit the truth, is equally true of material or solid substances. We have no *ideas* of solidity and extension, because these things are not originally impressed upon the senses; but we have very distinct though relative *notions* of them, for they are clearly perceived by the effects which they produce. That this is at least possible, we have the acknowledgement of Bishop Berkeley himself: for he "freely owns, that from a cause, effect, operation, sign, or other circumstance, there may reasonably be inferred the existence of a thing not immediately perceived; and that it were absurd for any man to argue against the existence of that thing, from his having no direct and positive notion of it." This is exactly the case with respect to solid substances. These substances we do not immediately perceive; but we infer their existence from effects, signs, and other circumstances, and we have of them very clear though relative notions. Thus a man can open and shut his empty hand; but when he grasps an ivory ball of three or four inches diameter, he feels, that though the same power be exerted, his hand cannot then be shut. He is conscious that there is no change in himself; and being intuitively certain that every effect must have a cause, he infers with the utmost confidence, that the cause which prevents his hand from shutting is in the ball; or, in other words, that the thing which communicates to his eye the sensation of colour, and impresses upon his hand a sensation of touch, must be solid or impenetrable. Solidity, however, is not the sensation itself; it is only the cause of the sensation; and therefore it is so far from being an idea in our minds, that we are conscious our notion of it is of a thing totally different from all our ideas, of a thing external, at least to our minds. Indeed the notion itself is not positive; it is only relative, and inferred from the effects which are produced on our senses. That it is the *same* thing which communicates to the eye the sensation of colour, and has the power of resisting the compression of our hand, is evident: because, when the ball is thrown away, the resistance as well as the actual sensation vanish at once.

171 e idea of our and : notion solidity t naturally insepa-le.

From this fact, which a less acute man would think a proof that the resistance was not occasioned by the immediate agency of the Supreme Being, but by the impenetrability of a solid substance of small dimensions, the bishop argues thus against the *possibility* of such a substance: "They who assert that figure, motion, and the rest of the primary or original qualities, do exist without the mind in unthinking substances, do at the same time acknowledge, that colours, sounds, heat, cold, and such like secondary qualities, do not; which they tell us are sensations existing in the mind alone, that depend on and are occasioned by the different size, texture, and motion, of the minute particles of matter. This they take for an undoubted truth, which they can demonstrate beyond all exception. Now if it be certain, that those original qualities are inseparably united with the other sensible qualities, and not even in thought capable of being abstracted from them, it plainly follows, that they exist only in the mind. But I desire any one to reflect and try whether he can by any abstraction of thought conceive the extension and motion of a body, without all other sensible qualities. For my own part, I see evidently that it is not in my power to frame an idea of a body extended and moved, but I must withal give it some colour or other sensible quality, which is acknowledged to exist only in the mind. In short, extension, figure, and motion, abstracted from all qualities, are inconceivable. Where, therefore, the other sensible qualities are, there must be these also, to wit, in the mind, and no where else."

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In this reasoning, though plausible, there is an unintended fallacy. It is indeed true, that we cannot contemplate in imagination a solid substance without conceiving it to have some colour; but there is sufficient reason to believe, that this union of colour and solidity in our minds is not the effect of nature as it operates at first upon our senses, but merely the consequence of early and deep-rooted association. Bishop Berkeley himself has taught us, that the objects of sight are not at a distance; and that if a man born blind were suddenly made to see, he would conceive the objects of his sight as existing either in his eye or in his mind. This is a truth which no man will controvert who has dipt into the science of optics, or who has even paid the slightest attention to the perceptions of infants; and if so, it follows, that to a man born blind and suddenly made to see, colour and solidity would not appear united. Were such a person to lay hold of an ivory ball and raise it to the elevation of his eye, he would perceive whiteness as a new sensation existing in his eye or his mind, but he would feel resistance at the extremity of his arm. He would not have the least reason to conclude, that this whiteness was inseparably united to the cause of this resistance; and he would, in fact, draw no such conclusion, till experience had taught him, that by removing the ball or cause of resistance from his hand, he at the same time removed the sensation from his eye. After repeated experiments, he would indeed discover, that the cause of colour to the eye, was likewise by some means or other the cause of resistance to the hand; and he would so associate these in his mind, that the one would never afterwards make its appearance as an idea or a notion without bringing the other along with it. The whole difficulty, therefore, in this case, is to break an early and deep-rooted association; for it is plain that the associated ideas were not originally united, and that solidity and colour were at first conceived as separate.

If the reader perceive not the force of this reasoning, we beg leave to recommend to him the following experiment, which, if we mistake not, will carry conviction to his judgment, that in the last-quoted passage Bishop Berkeley has argued fallaciously, and that extension and colour are not *inseparably* united as ideas in the mind. Let him go into a dark room, containing a number of spherical bodies of various colours; let him take one of them into his hand; and

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and he will instantly *feel* resistance, and have a *notion* of extension and solidity; but will he likewise have the *idea* of colour inseparably united with this notion? The bishop says he will: and if so, it must be the idea of some *particular* colour; for his lordship has taught us, that the *abstract* and *general* idea of colour, which is neither *red*, nor *green*, nor *blue*, &c. cannot possibly be formed. The man, then, we shall suppose, whilst he feels resistance, conceives the resisting body to be *green*; and holding it still in his hand, walks into the light of day. The *resistance*, and consequently the *cause* of resistance, remains unchanged; but what becomes of the inseparable union of those with colour, when the body, upon being actually seen, proves to be *black*, i. e. to have no colour at all?—It appears, therefore, undeniable, that solidity and colour are not united in nature; that the one is an essential quality of something external to us, of which we have no *idea*, but a very distinct though relative *notion*; and that the other is an actual sensation in our minds, caused by the impression of something external on the organ of sense, which leaves behind it in the memory or imagination a positive and direct *idea* that exists no where else.

172 Matter exists, but

Solid substance, therefore *may* exist; for though it is not immediately perceived by the senses, and is a thing of which we can have no *idea*, we acquire a clear and distinct *notion* of it, by the very same means which Bishop Berkeley thinks sufficient to give us distinct notions of power and of spirits; and, therefore, that notion can involve in it no contradiction. Still, however, we would not say with Dr Beattie, "that we could as easily believe, that two and two are equal to ten; or, that whatever is, is not; as that matter has no separate existence:" for it is certainly *possible*, that the Supreme Being, without the instrumentality of matter, could communicate to our minds all the sensations and notions from which we infer the reality of solid substance. All that we contend for, as having the evidence of demonstration, is the *possibility* of solid and extended substance; and if the thing be *possible*, the general voice of mankind proclaims its *probability*.—We are *conscious* of our actual sensations, and we know by *experience* that they are caused by something distinct from ourselves. When a man grasps an ivory ball, he *feels* that he cannot shut his hand, and he knows that the resistance which prevents him proceeds *not* from *himself*. Thus far all mankind are agreed. But Bishop Berkeley says, that the resistance proceeds immediately from the Supreme Being or some other spirit; whilst we, without pretending that his scheme is impossible, think it more natural to suppose that the man's hand is kept from shutting by the resistance of a solid substance of four inches diameter; of which substance, though we have no *idea* of it, we have as distinct a *notion* as Berkeley had of spirits. From one or other of these causes this effect must proceed; and it is of little importance to life or happiness which of them be the true cause, since it is with the effect only that we are immediately concerned. Still, however, a philosopher would choose to adopt the easiest and most natural side of every alternative; which, if our notion of solidity be just, is certainly, in the present case, the existence of matter.

After treating so largely of the composition of bodies, and showing the general agreement of metaphysicians, ancient and modern, with respect to the notion of their solidity, it will appear strange to the less philosophical part of our readers, that we should now express a doubt of that notion's being well-founded.— 173 is by some philosophers denied to be solid.
We have ourselves no doubt, but on the contrary are fully convinced, that solidity is essential to matter. This, however, has of late been denied by philosophers of great merit. Dr Priestley, after Mr Mitchell and Father Boscovich, affirms that matter is *not solid* or impenetrable to other matter; and that it has, in fact, no properties but those of *attraction* and *repulsion* *. The proofs of this position, which appears so paradoxical, he draws from optical experiments, from electricity, and from the effects of heat and cold upon substances usually conceived to be solid.

* *Disquisitions on Matter and Spirit* and *Correspondence with Dr Price.*

The appearances from which the solidity of matter is inferred, are nothing more, he says, than superficial appearances, and therefore have led to superficial and false judgments, which the *real appearances* will not authorize. "*Resistance*, on which alone our opinion concerning the solidity or impenetrability of matter is founded, is never occasioned by *solid matter*, but by something of a very different nature, viz. a *power of repulsion*, always acting at a real, and in general an assignable distance, from what we call the body itself. When I press my hand against the table, I naturally imagine that the obstacle to its going through the table, is the *solid matter* of which it consists; but a variety of philosophical considerations demonstrate that it generally requires a much greater power of pressure than I can exert to bring my fingers into actual contact with the table. Electrical appearances show that a considerable weight is requisite to bring into seeming contact even the links of a chain hanging freely in the air, they being kept asunder by a repulsive power belonging to a very small surface, so that they do not actually touch, though they are supported by each other. It has been shown, from optical considerations, that a drop of water rolls upon a cabbage leaf without ever coming into actual contact with it; and indeed all the phenomena of *light* are most remarkably unfavourable to the hypothesis of the solidity or impenetrability of matter. When light is reflected back from a body on which it seems to strike, it was natural to suppose that this was occasioned by its impinging against the *solid parts* of the body; but it has been demonstrated by Sir Isaac Newton, that the rays of light are always reflected by a *power of repulsion* acting at some distance from the body. Again, When part of a beam of light has overcome this power of repulsion, and has entered any transparent substance, it goes on in a right line, provided the medium be of a uniform density, without the least interruption, and without a single particle being reflected, till it comes to the opposite side, having met with no solid particles in its way, not even in the densest transparent substances, as glass, crystal, or diamond; and when it is arrived at the opposite side, it is solely affected by the laws of attraction and repulsion.

174 The arguments used in support of this hypothesis.

"Nay, that the component particles of the hardest bodies themselves do not actually touch one another, is demonstrable from their being brought nearer together by cold, and by their being removed farther from each other by heat. The power sufficient to overcome these

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these internal forces of repulsion, by which the ultimate particles of bodies are prevented from coming into actual contact, is what no person can pretend to compute. The power requisite to break their cohesion, or to remove them from the sphere of each other's attraction, may in some measure be estimated; but this affords no *data* for ascertaining the force that would be necessary to bring them into actual contact, which may exceed the other almost infinitely."

From these facts, Dr Priestley infers, that the mutual resistance of bodies proceeds in all cases from powers of repulsion acting at a distance from each body: that the supposition of the *solidity* or *impenetrability* of matter is destitute of all support whatever; and that matter itself is nothing but powers of attraction and repulsion, and several spheres of them, one within another. As other philosophers have said, "Take away solidity, and matter vanishes;" so he says expressly, "Take away attraction and repulsion, and matter vanishes."

To illustrate this strange notion, "Suppose (says he) that the Divine Being, when he created *matter*, only fixed certain *centres of various attractions and repulsions*, extending indefinitely in all directions, the whole effect of them to be upon each other, these centres approaching to, or receding from each other, and consequently carrying their peculiar spheres of attraction and repulsion along with them, according to certain definite circumstances. It cannot be denied that these spheres may be diversified infinitely, so as to correspond to all the kind of bodies that we are acquainted with, or that are possible. For all effects in which bodies are concerned, and of which we can be sensible by our eyes, touch, &c. may be resolved into attraction or repulsion. A compages of these centres, placed within the spheres of each other's attraction, will constitute a body that we term *compact;* and two of these bodies will, on their approach, meet with a repulsion or resistance sufficient to prevent one of them from occupying the place of the other, without a much greater force than we are capable of employing; so that to us they will appear perfectly hard.

"As in the constitution of all actual bodies that we are acquainted with, these centres are placed so near to each other, that in every division that we can make we still leave parts which contain many of these centres; we, reasoning by analogy, suppose that every particle of matter is infinitely divisible; and the *space* it occupies is certainly so. But, strictly speaking, as those centres which constitute any body are not absolutely infinite, it must be naturally possible to come by division to one single centre, which could not be said to be divisible, or even to occupy any portion of space, though its sphere of action should extend ever so far; and had only *one* such centre of attraction, &c. existed, its existence could not have been known, because there would have been nothing on which its action could have been exerted; and there being no *effect*, there could not have been any ground for supposing a *cause*."

[...]ee Dis-[...]ion be[...]n Dr [...]e and Priest-

In answer to this reasoning against the solidity of matter, Dr Priestley was frequently asked by his candid and masterly antagonist *, "What it is that attracts and repels, and that is attracted and repelled?" But to the question he was never able to give a satisfactory answer. Indeed, how could he have been able? for, as Dr Price argues, "Exclusive of attraction and repulsion, he affirms matter to be absolutely nothing; and therefore, though we were to allow it the power of attracting and repelling, yet as it is nothing but this power, it must be the power of nothing, and the very idea of it be a contradiction."

If there be any class of truths intuitively certain, that class comprehends the two following propositions: POWER CANNOT BE WITHOUT A SUBJECT; and NOTHING CAN ACT WHERE IT IS NOT. If, therefore, there be powers of attraction and repulsion, (which shall be considered afterwards in the Chapter of MOTION), there must be a subject of those powers; and if matter, whether solid or unsolid, be the subject, it cannot possibly attract or repel at a *distance*. Sir Isaac Newton, in his letters to Dr Bentley, calls the notion that matter possesses an innate power of attraction, or that it can act upon matter at a distance, and attract and repel by its own agency, "an absurdity into which, he thought, no one could possibly fall." Hence it follows, that the appearances from which Dr Priestley infers the penetrability of matter must be fallacious appearances, since they contradict an intuitive and necessary truth. The facts which he instances are, indeed, such as would make most other men suspicious of fallacy, and in his reasonings from them he sometimes takes for granted the truth to be proved. The links of a chain used for electrical purposes, supposing them to be in contact with each other, can touch only with very small surfaces. The electrical fluid is of considerable density, and incapable of being absorbed within a very narrow compass. This is evident, because it passes not through paper and other porous bodies without making a passage for itself, and leaving a visible aperture behind it; and though it assimilates with metals, and passes through them more easily than through other bodies, yet it is plain that it requires a certain quantity of metal to conduct it; for when the conductor falls short of the necessary quantity, it is melted or dissipated by the force of the fluid. This being the case, it follows that the links of a chain *may be* in actual contact (we do not positively affirm that they *are*), and yet the fluid become visible in passing from link to link; for if the point of contact be too small to absorb the *whole* fluid, *part* of it must pass without any metallic conductor through the atmosphere, and thus become apparent to the eye of the spectator.

175 founded on fallacious appearances and contrary to an intuitive and necessary truth.

With respect to light, it is obvious that there cannot possibly be any *demonstration*, in the logical sense of the word, that it is reflected by a power of repulsion acting at some distance from the body; for, in the opinion of all mankind, the primary and solid atoms of matter are too minute to fall under the cognizance of our senses, however assisted by art; and therefore, if light *appears* to be reflected at a distance from the surface of the body, we must conclude, either that between the point of reflection and the apparent surface of the body, there are solid atoms unperceived by us, or that light is reflected by the agency of some other substance than matter. One of these conclusions, we say *must* be drawn, because they are both *possible*, and there is no other alternative but to admit one of them, or to suppose that a thing may act where it is not;

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not; which is as clearly absurd and *impossible* as that *whatever is, is not*. Again, When part of a beam of light has entered any transparent substance, how does Dr Priestley know that it goes on in a right line, without the least interruption, till it comes to the opposite side? This he can know only by his senses; but the beam may meet with ten thousand interruptions from objects which the senses cannot perceive, and may describe a zig-zag line, of which the deflections are so small as to elude the keenest eye aided by the most powerful glass.

That the component particles of the hardest bodies do not *all* actually touch one another, is indeed evident from the effects of cold and heat upon those bodies: but it does not therefore follow that those bodies have no component particles; but only that they are fewer in number than we are apt to imagine; that all the solid matter in the universe might possibly be compressed within a very narrow sphere; and that it is held together in different bodies and different systems by a power foreign from itself. These are truths which all philosophers have admitted who have thought sufficiently on the subject; but who will admit Dr Priestley's proposition, when it is translated into common English: "That the component *nothings* of the hardest bodies do not actually touch one another, is demonstrable from their being brought nearer together by cold, and by their being removed farther from each other by heat?"

176 Our most adequate notion of matter.

Dr Priestley owns, that if matter be solid it could act upon other matter by impulse. We are certain, that, whatever it be, it can act upon nothing in the manner which he describes; and therefore, to use the words of Dr Price, "matter, if it be any thing at all, must consist of solid particles or atoms occupying a certain portion of space, and therefore *extended*, but at the same time *simple* and *uncompounded*, and incapable of being resolved into any other smaller particles. It must likewise be the different form of these *primary* particles, and their different combinations and arrangement, that constitute the different bodies and kinds of matter in the universe." This is exactly agreeable to the doctrines of Newton; who, after considering the question in every point of view, concludes, that "in the beginning God formed matter in solid, massy, hard, impenetrable, moveable particles, of such sizes and figures, and with such other properties, as most conduced to the end for which he formed them; and that those primary particles being solid, are incomparably harder than any porous bodies compounded of them; even so very hard as never to wear or break in pieces: no ordinary power being able to divide what God himself made one in the creation." To talk, as Dr Priestley does, of matter's being certain *centres of various attractions and repulsions* extending indefinitely in all directions, and to describe these centres as *not* being *physical points* or *solid atoms*, is either to say, that *nothing* attracts and repels; or it is to introduce the divine agency as the immediate cause of all our sensations. The former of these alternatives Dr Priestley disclaims; the latter he seems willing to admit. But if it be his meaning that all our sensations are caused by the immediate agency of God or created spirits, his scheme differs not from that of Berkeley, except in being less elegantly expressed and less ingeniously supported. Berkeley's scheme is evidently *possible*. The commonly received scheme is likewise possible. It remains therefore with the reader, whether he will adopt the system of the Bishop of Cloyne; or admit, with all other philosophers, that matter exists; that it consists of parts actually distinct and separable; and that each of these parts is a *monad* or solid atom, which requires no foreign agency to keep it united.

Chap. IV. *Of* Space *and its* Modes.

177 The necessary adjuncts of body, what.

Having considered bodies in their substance, essences and qualities, and proved that they have a real existence independent of us and our conceptions, we proceed now to inquire into the nature of *space*, *motion*, *number*, and *duration*. These are commonly called the *adjuncts* of body, and are supposed to be absolutely inseparable from its existence. It does not indeed appear that *actual motion* is a necessary adjunct of body, considered as a mere solid, extended, and figured substance; but it is certainly necessary to the existence of organized and animated bodies, and the capability of being moved enters into our conceptions of all bodies whatever. Of these adjuncts, that which first demands our attention is *space*: for without a knowledge of its nature we could not have an adequate idea of motion, and without motion we could have no idea of time.

178 Our notion of space, how acquired.

Every body is extended; and between two bodies not in actual contact, we perceive that a third body may be easily introduced. That which admits of the introduction of the third body is what we call *space*: and if it be totally void of matter, it is called *pure space*. Whether there be any space absolutely pure, has been disputed; but that such space is possible, admits of no dispute. Were any one body (a cannon ball for instance) to be annihilated, and the circumambient air, with every other material substance, kept from rushing into the space which the ball had occupied, that portion of space, with respect to matter, would be empty or pure space: whether it would necessarily be filled with mind shall be considered afterwards. Pure space, therefore, is conceivable; and it is conceived as having three dimensions, length, breadth, and depth, which are generally called the three simple modes of space. In this respect it agrees with body: but the agreement proceeds no farther; for space is conceived as destitute of solidity, without which the existence of body is inconceivable. It has been formerly observed, that whatever may be distinctly conceived may possibly exist; but with respect to the existence of pure space, whatever is possible is real: for it shall be shown in the next section, that were there no space absolutely pure or void of matter, there could be no motion. Our business at present is to inquire what the nature of space is, and what notion we ought to have of its existence.

179 Space supposed to be something different from body and mind, and to be eternal and infinite, &c.

Many modern philosophers consider space as something entirely distinct both from body and mind: some of them ascribe to it no less than four of the attributes of the Deity—*eternity*, *immobility*, *infinity*, and *necessary existence*; and a few of them have gone so far as to call *infinite space* the *sensorium* of the Deity. "The supposal of the existence of *any thing whatever* (says Dr Clarke)

Space its Modes.

Clarke *) necessarily includes a *presupposition* of the existence of *space*. Nothing can possibly be conceived to exist without thereby presupposing space; which, therefore, I apprehend to be a *property* or *mode* of the self-existent Substance; and that, by being evidently necessary itself, it proves, that the substance of which it is a property must be also necessary." Elsewhere he says, that "space is a property or mode of the self-existent Substance, but not of any other substances. All other substances are *in* space, and are *penetrated* by it; but the self-existent Substance is not in space, nor penetrated by it, but is itself (if I may so speak) the *substratum* of space, the *ground* of the existence of *space* itself." He acknowledges, however, that such expressions as "the self-existent Substance is the *substratum* of space, or space is a property of the self-existent Substance, are *not*, perhaps, very proper: but what I mean (says he), is this: The idea of *space* (as also of *time* or *duration*) is an abstract or partial idea; an idea of a certain *quality* or *relation*, which we evidently see to be necessarily existing; and yet which (not being itself a *substance*) at the same time necessarily *presupposes* a substance, without which it could not exist."

These opinions respecting space have been adopted by succeeding philosophers of great merit, and particularly by Dr Price; who says, that "it is a maxim which cannot be disputed, that *time* and *place* are necessary to the existence of all things. Dr Clarke (continues he) has made use of this maxim, to prove that infinite space and duration are the essential properties of the Deity; and I think he was right."

Had authority any weight in philosophy, we know not what modern writers we could oppose to the celebrated names of Clarke and Price, unless it were Bishop Berkeley, Dr Law late bishop of Carlisle, and the author of Ancient Metaphysics. But the question is not to be decided by authority. Learned and acute as Dr Clarke was, his assertions respecting space are contradictory and inconsistent. If nothing can possibly be conceived to exist without thereby presupposing the existence of *space*, how can space be a property or mode of the self-existent Substance? Are properties prior in the order of nature, or even in our conceptions, to the substances in which they inhere? Can we frame an abstract idea of figure, or extension, or solidity, before we conceive the existence of any one figured, extended, or solid substance? These are questions which every man is as capable of answering as the Doctors Clarke and Price, provided he can look attentively into his own mind, and trace his ideas to their source in sensation: and if he be not biassed by the weight of great names, we are persuaded he will find, that if it be indeed true, that the supposal of the existence of any thing whatever necessarily includes a *presupposition* of the existence of space, *space* cannot possibly be a *property* or *mode* of the self-existent Substance, but must of necessity be a *substance* itself.

It is, however, *not* true, that the supposal of the existence of any thing whatever necessarily includes a presupposition of the existence of space. The idea of space is indeed so closely associated with every visible and tangible object, that we cannot see the one nor feel the other without conceiving them to occupy so much of space. But had we never possessed the senses of sight and touch, we could not have supposed the existence of space necessary to the existence of any thing whatever. The senses of smelling, tasting, and hearing, together with our internal powers of consciousness and intellect, would certainly have compelled us to believe in our own existence, and to suppose the existence of other things; but no object either of consciousness, smelling, tasting, or hearing, can be conceived as occupying space. Space and every thing which fills it are conceived as of three dimensions; but who ever supposed or can suppose an *odour*, *taste*, or *sound*, to have *length*, *breadth*, and *depth*; or an object of consciousness to be an ell or an inch long?

Let us suppose that body and all the visible world had a beginning, and that once nothing existed but that Being which is alone of necessary as well as eternal existence; *space*, say the followers of Dr Clarke, would then exist likewise without bounds or limits. But we desire to know of these gentlemen what sort of a being this space is. It certainly is not *substance*; neither is it a property; for we have seen that the very notions of it, which lead men to suppose its existence *necessary*, render it impossible to be a property of the self-existent Being. Is it then nothing? It "is in one sense *: it is nothing *actually* existing; but it is something *potentially*; for it has the *capacity* of receiving body whenever it shall exist. It is not, and cannot become any thing itself, nor hath it any actual existence; but it is that without which nothing corporeal could exist." For this reason it was that Democritus and Epicurus made space one of the principles of nature; and for the same reason Aristotle has made *privation* one of his three principles of natural things, *matter* and *form* being the other two. But though the privation of *one* form be doubtless necessary before matter can receive another (for a piece of wax or clay cannot receive the form of a *globe* before it lose the form of a square), yet Aristotle never dreamed that the privation of the square was any property of the globe, or that *privation* itself was to be reckoned a real being. On the contrary, he expressly calls it το μη ον, or *the no being*. In this way, if we please, we may consider space, and call it the *privation of fulness* or of body. We have indeed a positive idea of it, as well as of silence, darkness, and other privations: but to argue from such an idea of space, that space itself is something real, seems altogether as good sense as to say, that because we have a different idea of *darkness* from that of *light*, of *silence* from that of *sound*, of the *absence* of any thing from that of its *presence*; therefore *darkness*, *silence*, *absence*, must be real things, and have as positive an existence as *light*, *sound*, and *body*: and to deny that we have any positive idea, or, which is the very same thing, any idea at all, of the privations above mentioned, will be to deny what is capable of the most complete proof (see N° 19.), and to contradict common sense and daily experience. There are therefore ideas, and simple ones too, which have nothing *ad extra* correspondent to them; no proper *idictum*, archetype, or objective reality: and we do not see why the idea of space may not be reckoned of that number. To say that *space* must have existence because it has some properties (for instance, *penetrability*, or the *capacity* of receiving body), seems † to be the same thing as to urge that *darkness* must be *something* because it has the capacity of *receiving light*; *silence* the property of admitting

* *Ancient Metaphysics.*

† See *Notes on King's Origin of Evil*, and *Law's Enquiry into the Ideas of Space, &c.*

Of Space and its Modes.

admitting *sound;* and *absence* the property of being supplied by *presence.* To reason in this manner is to assign absolute negations; and such as, in the same way, may be applied to *nothing*, and then call them *positive properties;* and so infer that the chimera, thus clothed with them, must needs be *something*.

182 Space nothing but the possible existence of body.

But it is said, that as we cannot conceive space to be annihilated, it must be some real thing of eternal and necessary existence. If this argument had not been used by writers of great merit, and with the best intention, we should not have scrupled to call it the most contemptible sophism that ever disgraced the page of philosophy. Whatever now has an *actual* existence, must from eternity have had a *possible* existence in the ideas of the Divine mind. Body, as an extended substance, has now an *actual* existence; and therefore it must from eternity have had a *possible* existence in the ideas of the Divine mind: but the *possible existence of body* is all that we can conceive by *space;* and therefore this argument, upon which so much stress has been laid, amounts to nothing more, than that what has from eternity been possible, can at no period have been impossible. It is evident that the *capacity* or *potentiality* of every thing existing must have been from eternity; but is capacity or potentiality a real being? All the men and women who shall succeed the present generation to the end of time, have at this moment a possibility of existence, nor can that possibility be conceived as an impossibility; but is it therefore any thing actually existing either as a substance or a quality?

It has been urged, that space must be something more than the mere absence of matter; because if nothing be between bodies, such as the walls of a room, they must necessarily touch. But surely it is not *self-evident* that bodies must necessarily touch if nothing be between them; nor of the truth of this proposition can any thing like a proof be brought. It is indeed intuitively certain, that "things, when they are in contact, have nothing between them:" and hence it has rashly been inferred, that things, when they have nothing between them, are in contact; but this is an illegitimate conversion of the proposition. Every logician knows, that to convert a proposition, is to infer from it another whose *subject* is the *predicate*, and whose *predicate* is the *subject*, of the proposition to be converted: but we are taught by Aristotle and by common sense, that an *universal* affirmative can be converted only into a *particular* affirmative. "Things, when they are in contact, have nothing between them," is an *universal* affirmative proposition; and therefore it can be converted only into the following *particular* affirmative: "Some things, when they have nothing between them, are in contact;" a proposition which by no means includes in it the contact of the walls of an empty room. The reason why the walls of an empty room do not touch, is that they are *distant;* but is *distance*, in the abstract, any thing really existing? Two individuals differ, or there is a difference between them; but is *difference* itself any real external thing? Bodies are long, broad, thick, heavy; but are *length*, *breadth*, *density*, *weight*, properly any thing? Have they any real separate archetypes or external idiata? Or can they exist but in some substance?

183 The fallacy which leads to the supposition that space is a real thing.

The reason why so many philosophers have considered space as a real external thing, seems to be this: Every bodily substance is extended; but space is conceived to be that which contains body, and therefore to space we likewise attribute extension. Extension is a quality which can have no existence but as united with other qualities in some substance; and it is that of which, abstracted from all substances, we can, properly speaking, form no *idea*. We understand the meaning of the word, however, and can reason about that which it denotes, without regarding the particular substance in which extension may inhere; just as we can reason about whiteness without regarding any one white object, though it is self-evident that whiteness, abstracted from all objects, cannot figure in the mind as an idea. Qualities considered in this manner are general and relative notions, the objects of pure intellect, which make no appearance in the imagination, and are far less, if possible, to be perceived by sense: but it is extremely painful to the mind to dwell upon such notions; and therefore the ever-active fancy is always ready to furnish them with imaginary *substrata*, and to make that which was a *general* and *invisible notion* be conceived as a *particular ideal object*. In the case of extension this is the more easily done, that the notion which we have of a *real substratum* or substance, the support of real qualities, is obscure and relative, being the notion of *something* we know not what. Now, by leaving, if we can, solidity and figure out of our conception, and joining the notion of *something* with the notion of *extension*, we have at once the *imaginary substratum* of an *imaginary* quality, or the general notion of extension particularized in an imaginary subject; and this subject we call *space*, vainly fancying that it has a real external and independent existence. Whether this be not all that can be said of space, and whether it be not absurd to talk of its having any real properties, every man will judge for himself, by reflecting upon his own ideas and the manner in which they are acquired. We ourselves have no doubt about the matter. We consider pure space as a mere notion relative to the existence of corporeal substance, as nothing more than the absence of body, where body is possible; and we think the usual distinction between *absolute* and *relative* space, if taken as real, the grossest absurdity. We do not, however, pretend to dictate to others; but recommend it to every man to throw away all respect for great names, to look attentively into his own thoughts, and on this as on all metaphysical subjects to judge for himself.

184 Place, what it is.

Having said so much of space in general, we need not waste much time upon its modes. Indeed the only mode of space, after considering it with respect to the three dimensions of body, which now demands our attention, is that which we call *place*. As in the simplest mode of space we consider the relation of distance between any two bodies or points; so, in our idea of *place*, we consider the relation of distance betwixt any thing, and any two or more points, which, being considered as at rest, keep the same distance one from another. Thus, when we find any thing at the same distance now at which it was yesterday from two or more points with which it was then compared, and which have not since the comparison was made changed their f Space nd its Iodes.

their distance or position with respect to each other, we say that the thing hath kept its *place*, or is in the *same place*; but if it hath sensibly altered its distance from either of these points, we then say that it hath changed its *place*.

From this view of the nature of place, we need not observe that it is a mere relation; but it may be worth while to advert to this circumstance, that a thing may without falsehood be said to have continued in the same place, and at the same time to have changed its place according to the different objects with which it is compared. Thus, if two persons find a company of chess-men standing each upon the same square of the chess-board where they left them, the one may with truth affirm that they are all in the *same place*, or unmoved; and the other may with equal truth affirm that they have all changed *place*. The former considers the men only with respect to their distances from the several parts of the chess-board, which have kept the same distance and position with respect to one another. The latter must consider the men with respect to their distance from something else: and finding that the chess-board, with every thing upon it, has been removed, we shall suppose, from one room to another, he cannot but say that the chess-men have changed their place with respect to the several parts of the room in which he formerly saw them.

This modification of distance, however, which we call *place*, being made by men for their common use, that by it they may design the particular position of objects where they have occasion for such designation, they determine this *place* by reference to such adjacent things as best serve their present purpose, without regarding other things which, for a different purpose, would better determine the place of the same object. Thus in the chess-board, the use of the *designation of the place* of each chess-man being determined only within that chequered piece of wood, it would cross that purpose to measure it by any thing else: but when these very chess-men are put up in a box, if any one should ask where the black king is, it would be proper to *determine the place* by reference to something else than the chess-board; such as the parts of the room or closet which contain the box.

185 e universe has place.

That our idea of *place* is nothing but such a relative position of things as we have mentioned, will be readily admitted, when it is considered that we can have no idea of the place of the *universe*. Every *part* of the universe has place; because it may be compared with respect to its distance from other parts supposed to be fixed. Thus the earth and every planet of our system has a place which may be determined by ascertaining its distance from the sun and from the orbits of the other planets; and the place of the system itself may be ascertained by comparing it with two or more fixed stars: but all the systems taken as *one whole* can have no *place*; because there is nothing else to which the distance and position of that whole can be referred. It is indeed true, that the word *place* is sometimes used, we think improperly, to denote that *space* or portion of *space* which any particular body occupies; and in this sense, no doubt, the universe has place, as well as the earth or solar system: but to talk of the place of the universe in the other and proper sense of the word, is the grossest nonsense.

Chap. V. *Of* Motion.

Of Motion.

Mobility, or a capacity of being moved, is essential to every corporeal substance; and by actual motion are all the operations of nature performed. Motion, therefore, if it may be called an *adjunct* of body, is certainly the most important of all its adjuncts; and to ascertain its nature and origin demands the closest attention of the metaphysician, as well as of the mechanic and astronomer. With the *laws* of motion, as discovered by experience, we have at present no concern: they are explained and fully established in other articles of this work (See Mechanics, Motion, &c.) The principal questions which we have to consider are: "What is motion? and, By what power is it carried on?"

186 Mobility essential to every corporeal substance, but not natural motion.

For an answer to the first of these questions, the modern metaphysician refers every man to his own senses; because, in his apprehension, the word motion denotes a simple idea which cannot be defined. Among the ancients, the Peripatetics were of a different opinion; and Aristotle, whose love of dialectic made him define every thing, has attempted to give two definitions of *motion*. As some learned men are at present labouring to revive this system, we shall, out of respect to them, mention those definitions, and make upon them such remarks as to us appear proper.

187 The Peripatetic definitions of motion.

The author of *Ancient Metaphysics* having observed, that both nature and art propose some end in all their operations; that when the end is obtained, the thing operated upon is in a state of perfection or completion; and that in the operations of both nature and art there is a progress, and by consequence a *change* from one thing to another; adds, that this change is *motion*. Motion, therefore, according to him, is a change or progress to the end proposed, or to that state of perfection or completion which Aristotle calls εντελεχεια. It is not enough, however, that we know *to what* the change or progress is made: to have an adequate idea of motion, we must likewise know *from what* it proceeds. Now it is evident that every thing existing, whether by nature or art, was, before it existed, possible to exist; and therefore, adds the same author, things do in some sort exist even before they exist. This former kind of existence is said by Aristotle to be εν δυναμει, that is, in *power* or *capacity*. In this way, plants exist in their seeds; animals in the embryo; works of art in the idea of the artists and the materials of which they are made; and, in general, every thing in the causes which produce it. From this power or capacity there is a progress to *energy* or actual existence; so that we are now able to answer the question, "*from what*, and *to what*, motion is a change?" for it is universally true of all *motion*, that it is a change from *capacity* to *energy*.

"Having thus discovered that *motion* lies betwixt *capacity* and *energy*, it is evident (he says) that it must have a connexion with each of them: and from this double connexion Aristotle has given us two definitions of it; one of them taken from the *energy*, or end to which it tends; the other from the *capacity* from which it begins. The first is expressed in two words, viz. ενεργεια ατελης, or *imperfect energy*; the other is εντελεχεια

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του εν δυναμει ἡ εν δυναμει; which may be translated thus, *The perfection of what is in capacity, considered merely as in capacity.* The meaning of the last words is, that nothing is considered in the thing that is moved but merely its *capacity;* so that motion is the perfection of that capacity, but not of the thing itself. It is something more (adds the learned author) than mere *capacity;* for it is capacity exerted, which when it has attained its end, so that the thing has arrived at that state to which it is destined by nature or art, ceases, and the thing begins to exist ενεργεια, or *actually.*

188 unintelligible.

By all the admirers of Aristotle, this latter definition has been preferred to the former: for what reason, it is difficult to say. They both involve in the thickest obscurity that which, viewed through the senses, is very easily understood; and on this, as on many other occasions, Aristotle was certainly guilty of darkening counsel by words without knowledge. The author, whose comment on this wonderful definition we have faithfully abridged, admits that it is not intelligible till we know what *change* and *progress* are; but is it possible to conceive any *change* to take place in bodily substances without *motion?* or, if we were called upon to explain what progress is, could we do it better than by saying that it is motion *from* something *to* something? It is likewise very obvious that before we can have an adequate idea of *motion,* we must, according to this definition, know perfectly what the words *capacity, energy,* and *perfection* denote; and yet nothing can be more true than that *perfection* denotes a complex conception, which may be easily defined by resolving it into the simple ideas and notions of which it is compounded, whilst *motion* is susceptible of no such resolution. The perfection of a knife is compounded of the temper of the steel and the sharpness of the edge: the perfection of a system of philosophy consists of the importance of the subjects treated, the strength of the author's arguments, and the perspicuity of his style and manner; but of what is the *motion* of a ball, or an *atom,* or any thing else, compounded? We are aware that to this question the modern Peripatetics will reply, That it is not the motion of a *ball,* or an *atom,* or any *one thing,* that their master has so learnedly defined, but motion abstracted from *all individuals,* and made an object of pure intellect; and they will likewise affirm, that by the word *perfection* used in the definition, he does not mean *any one kind* of perfection as adapted to any particular *object* or *end,* but perfection abstracted from *all objects* and *all ends.* The perfection of *nothing* and the motion of *nothing,* for such surely are that motion and that perfection which are abstracted from *all objects* and *ends,* are strange expressions. To us they convey no meaning; and we have reason to think that they are equally unintelligible to men of greater acuteness (o). In a word, *motion* must be seen or felt; for it cannot be defined. To call it the *act of changing place,* or a *passage from one place to another,* gives no information; for *change* and *passage* cannot be conceived without previously conceiving *motion* (p).

189 The Peripatetic division of motion absurd.

The Peripatetics having idly attempted to *define* motion, proceed next to *divide* it into four kinds or classes. This division was by the father of the school pretended to be made from the effects which it produces, and was said by him to belong to three categories, viz. *quality, quantity,* and *where,* (see CATEGORY). The first kind is that well-known *motion* from *place* to *place,* which falls under the category last mentioned; the second is *alteration,* by which the quality of any thing is changed, the substance remaining the same. This belongs to the category of *quality.* The third is *increase,* and the fourth *diminution,* both belonging to the category of *quantity.* The ancient atomists, and all the modern metaphysicians of eminence, have with great propriety rejected this division, as being nothing but a collection of absurd distinctions where there is in nature no difference. It has been already shown, that body has no other real qualities than *solidity, extension,* and *figure:* but of these the first cannot be altered without destroying the substance; for every thing which is material is equally solid. The extension of a body may indeed be enlarged, and its figure may be altered, while the substance remains the same: but that alteration can be made only by moving from their *places* the solid atoms of which the body is composed. Aristotle's second kind of motion therefore differs not from the first; nor do the third and fourth differ from these two. For a body cannot be *increased* without acquiring new matter, nor diminished without losing some of the matter of which it was originally

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(o) "Nunc dicendum de natura motus. Atque is quidem, cum sensibus clarè percipiatur, non tam natura sua, quam doctis philosophorum commentis obscuratus est. Motus nunquam in sensus nostros incurrit sine mole corporea, spatio et tempore. Sunt tamen qui motum, tanquam ideam quandam simplicem et abstractam, atque *ab omnibus aliis rebus sejunctam,* contemplari student. Verum idea illa tenuissima et subtilissima *intellectus aciem eludit:* id quod quilibet secum meditando experiri potest. Hinc nascuntur magnæ difficultates de natura motus, et definitiones, ipsa re quam illustrare debent longe obscuriores. Hujusmodi sunt definitiones illæ Aristotelis et scholasticorum, qui motum dicunt esse *actum mobilis quatenus est mobile,* vel *actum entis in potentia quatenus in potentia.* Hujusmodi etiam est illud viri inter recentiores celebris, qui asserit *nihil in motu esse reale præter momentaneum illud quod in vi ad mutationem nitente constitui debet.* Porro constat, horum et similium definitionum auctores in animo habuisse abstractam motus naturam, seclusa omni temporis et spatii consideratione, explicare: sed qua ratione abstracta illa motus quintessentia (ut ita dicam) intelligi possit non video."

Berkeley de Motu.

(p) "Multi etiam per *transitum* motum definiunt, obliti scilicet transitum ipsum sine motu intelligi non posse, et per motum definiri opportere: Verissimum adeo est definitiones, sicut nonnullis rebus lucem, ita vicissim aliis tenebras afferre. Et prefecto, quascumque res sensu percipimus eas clariores aut notiores definiendo efficere vix quisquam potuerit. Cujus rei vana spe allecti res faciles difficillimas reddiderunt philosophi, mentesque suas difficultatibus, quas ut plurimum ipsi peperissent, implicavere." *Id. ibid.*

originally composed: but matter can neither be added nor taken away without motion from place to place; for there is now no creation *de novo;* and we have no reason to imagine that, since the original creation, a single atom has been ever annihilated. It is therefore past dispute, that local motion is the only motion conceivable; and indeed, as far as we are capable of judging from what we know of body, it is the only motion possible.

190 Whether, if but one body existed, there could be motion?

This has given rise to a question which has been debated among modern philosophers, though, as far as we know, it was never agitated among the ancients, viz. "Whether, if there were but one solid body existing, that body could possibly be moved." Bishop Berkeley seems to be of opinion that it could not; because no motion can be conceived but what has a direction towards some *place*, and the relation of place necessarily supposes the existence of two or more bodies. Were all bodies, therefore, annihilated except one globe, it would be impossible (he thinks) to conceive that globe in motion (Q). With respect to the origin of our *ideas* of motion, his reasoning appears unanswerable; but we do not perceive how it concludes against the possibility of motion itself as existing in a single body. It has been already shewn in the chapter of *Simple Apprehension and Conception*, that though nothing can be conceived which may not possibly exist, yet many things may be possible which we have not faculties or means to conceive. In the present instance, were this solitary globe animated as our bodies are, were it endowed with all our senses and mental powers, it certainly would not acquire any *idea* of motion though impelled by the greatest force. The reason is obvious; it would have no objects with which to compare its place and situation at different periods of time; and the experience of a ship at sea in calm weather, affords sufficient proof that motion which is equable cannot be perceived by any other means than by such a comparison. When the waves swell and the ship pitches, it is indeed impossible that those who are on board should not perceive that they are actually in motion; but even this perception arises from comparing their position with that of the waves rising and falling around them: whereas in the regions of empty space the animated globe could compare its position with nothing; and therefore, whether impelled by equal or unequal forces, it could never acquire the *idea* of motion. It may perhaps be thought, that if this solitary globe were a *self*-moving animal, it might acquire the *idea* of motion by inferring its existence from the energy which produced it. But how, we would ask, could an animal in such circumstances be *self*-moving? Motion is the effect of some cause; and it has been already shewn (See N° 117. of this article), that we have no reason to suppose that any being can be the *real* and *primary* cause of any effect which that being can neither conceive nor will: but as motion can be perceived only by the senses, a solitary animal could have no idea of motion previous to its own exertions; and therefore could neither conceive, nor will, an exertion to produce it. Let us, however, suppose, that without any end in view it might spontaneously exert itself in such a manner as would produce *sensible* motion, were it surrounded with other corporeal objects; still we may venture to affirm, that so long as it should remain in absolute solitude, the being itself would acquire no *idea* of motion. It would indeed be *conscious* of the *mental* energy, but it could not infer the existence of motion as a consequence of that energy; for the idea of motion can be acquired only by sense, and by the supposition there are no objects from which the senses of this spherical animal could receive those impressions, without which there can be no perception, and of course no ideas.

Let us now suppose, that, while this animated globe is under the influence either of external impulse or its own spontaneous energy, other bodies are suddenly brought into existence: would it then acquire the idea of motion? It certainly would, from perceiving its own change of place with respect to those bodies; and though at first it would not perhaps be able to determine whether itself or the bodies around it were moving, yet a little experience would decide this question likewise, and convince it that the motion was the effect either of its own *mental energy*, or that external *impulse* which it had felt before the other bodies were presented to its view. But it is obvious, that the creation of new bodies at a distance, can make no real alteration in the state of a body which had existed before them; and therefore, as this animated globe would now *perceive* itself to be moving, we may infer with the utmost certainty that it *was* moving 191 Answered in the affirmative.

(Q) Having proved that *place*, in the proper sense of the word, is merely relative, and affirmed that all *motion* is relative likewise, the bishop proceeds thus: "Veruntamen ut hoc clarius appareat, animadvertendum est, motum nullum intelligi posse sine determinatione aliqua seu directione, quæ quidem intelligi nequit, nisi præter corpus motum, nostrum etiam corpus, aut aliud aliquid, simul intelligatur existere. Nam sursum, deorsum, sinistrorsum, dextrorsum, omnesque plagæ et regiones in relatione aliqua fundantur, et necessario corpus à motu diversum connotant et supponunt. Adeo ut, si, reliquis corporibus in nihilum redactis, globus, exempli gratia, unicus existere supponatur; in illo nullus motus concipi possit: usque adeo necesse est, ut detur aliud corpus, cujus situ motus determinare intelligatur. Hujus sententiæ veritas clarissima elucebit, modo corporum omnium tam nostri quam aliorum, præter globum istum unicum, annihilationem rectè supposuerimus.

"Concipiantur porro duo globi, et præterea nihil corporeum, existere. Concipiantur deinde vires, quomodocunque applicari: quiequid tandem per applicationem virium intelligamus, motus circularis duorum globorum circa commune centrum nequit per imaginationem concipi. Supponamus deinde cœlum fixarum creari: subito ex concepto appulsu globorum ad diversas cœli istius partes motus concipietur. Scilicet cum motus natura sua sit relativus, concipi non potuit priusquam darentur corpora correlata. Quemadmodum nec ulla relatio alia sine correlatis concipi potest." *De Motu*.

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moving before; and that the motion of a single body, though not *perceivable* by the senses, might possibly be produced in empty space.

192 Whether motion would be possible in space absolutely full?

Having thus seen that a single body is capable of motion in empty space, the next question that occurs on this subject is, Whether it would be possible to move a body in space that is absolutely full? Such are the terms in which this question is usually put; and by being thus expressed, it has given rise to the dispute among natural philosophers about the existence of a *vacuum*. Perhaps the dispute might have been avoided had the question been more accurately stated. For instance, had it been asked, whether motion would be possible, could matter be supposed absolutely infinite without any the least interstice or vacuity among its solid parts? We apprehend that every reflecting man would have answered in the negative. At any rate, the question ought to be thus stated in metaphysics; because we have seen that space, though a positive term, denotes nothing really existing. Now it being of the very essence of every solid substance to exclude from the place which it occupies every other solid substance, it follows undeniably, that not one particle of an infinite solid could be moved from its place without the previous annihilation of another particle of equal extent; but that annihilation would destroy the infinity. Were matter extended to any degree *less* than infinity, the motion of its parts would undoubtedly be possible, because a sufficient force could separate those parts and introduce among them vacuities of any extent; but without vacuities capable of containing the body to be moved, it is obvious that no force whatever could produce motion. This being the case, it follows, that however far we suppose the material universe extended, there must be vacuities in it sufficient to permit the motion of the planets and all the other heavenly bodies, which we plainly perceive to revolve round a centre; and if so, the next question to be determined is, What can *in vacuo* operate upon such immense bodies, so as to produce a regular and continued motion?

193 Bodies equally indifferent to motion and rest.

That all bodies are equally capable of motion or rest, has by natural philosophers been as completely proved as any thing can be proved by observation and experience. It is indeed a fact obvious to the most superficial observer; for if either of these states were essential to matter, the other would be absolutely impossible. If rest were essential, nothing could be moved; if motion were essential, nothing could be at rest, but every the minutest atom would have a motion of its own, which is contrary to universal experience. With respect to motion and rest, matter is wholly passive. No man ever perceived a body inanimated begin to move, or when in motion stop without resistance. A billiard ball laid at rest on the smoothest surface, would continue at rest to the end of time, unless moved by some force extrinsic to itself. If such a ball were struck by another ball, it would indeed be moved with a velocity proportioned to the impetus with which it was struck; but the impelling ball would lose as much of its own motion as was communicated to that upon which the impulse was made. It is evident, therefore, that in this instance there is no *beginning* of motion, but only the communication of motion from one body to another; and we may still ask, Where had the motion its origin? If the impelling ball was thrown from the hand of a man, or struck with a racket, it is plain that by a volition of the man's mind the motion was first given to his own arm, whence it proceeded through the racket from one ball to another; so that the ball, racket, and arm, were mere instruments, and the mind of the man the only agent or first mover. That motion can be *begun* by any being which is not possessed of life, consciousness, and will, or what is analogous to these, is to us altogether inconceivable. Mere matter or inanimated body can operate upon body only by impulse: but impulse, though from the poverty of language we are sometimes obliged to talk of its agency, is itself merely an effect; for it is nothing more than the contact of two bodies, of which one at least is in motion. An infinite series of effects without a cause is the grossest absurdity; and therefore motion cannot have been communicated from eternity by the impulse of body upon body, but must have been originally produced by a being who acts in a manner analogous to the energies of the human will.

194 Motion produced by impulse can only be in a straight line.

But though motion could not have been begun but by the energy of mind, it is generally believed that it might be continued by the mere passivity of body; and it is a law of the Newtonian philosophy, that a body projected in empty space would continue to move in a straight line for ever. The only reason which can be assigned for this law is, that since body continues to move at all after the impetus of projection has ceased, it could not of itself cease to move without becoming active; because as much force is required to stop a body in motion as to communicate motion to the same body at rest. Many objections have been made to this argument, and to the law of which it is the foundation; but as we do not perceive their strength, we shall not fill our page with a formal examination of them (R). If a single body could exist and have motion communicated to it *in vacuo* by the force

(R) By much the strongest and best urged of these objections which we have seen, is made by Dr Horsley, a man equally learned in mathematics and in ancient and modern philosophy. "I believe with the author of Ancient Metaphysics (says he), that some active principle is necessary for the continuance as well as for the beginning of motion. I know that many Newtonians will not allow this: I believe they are misled, as I myself have formerly been misled, by the expression *a state of motion*. Motion is a change; a continuance of motion is a farther change; a farther change is a repeated effect; a repeated effect requires a repeating cause. State implies the contrary of change; and motion being change, a *state of motion* is a contradiction in terms." See *Ancient Metaphysics*, vol. ii.

If our readers think this reasoning conclusive, they may be in the right; and in that case they will see the necessity of admitting, even for the continuance of rectilineal motion, *the plastic nature*, or something equivalent

to

force of projection, we are persuaded, that from the very passivity of matter, that motion would never have an end; but it is obvious that it could be moved only in a straight line, for an impulse can be given in no other direction.

95
T[illegible] New- [illegible]n doc- [illegible] re- [illegible]ing the [illegible]s of [illegible]otion of [illegible] hea- [illegible] bo- [illegible]

The heavenly bodies, however, are not moved in straight lines, but in curves round a centre; and therefore their motion cannot have been originally communicated merely by an impressed force of projection. This is admitted by all philosophers; and therefore the Newtonians suppose that the planets are moved in elliptical orbits by the joint agency of two forces acting in different directions. One of these forces makes the planet tend directly to the centre about which it revolves: the other impels it to fly off in a tangent to the curve described. The former they call *gravitation*, which some of them have affirmed to be a property inherent in all matter; and the latter, which is a projectile force, they consider as impressed *ab extra*. By the joint agency of such forces, duly proportioned to each other, Sir Isaac Newton has demonstrated, that the planets must necessarily describe such orbits as by observation and experience they are found actually to describe. But the question with the metaphysician is, Whether such forces be real?

96
M[illegible]al at- tr[illegible]on a- m[illegible] the he[illegible]nly bo[illegible]s im- po[illegible]le.

With respect to projection, there is no difficulty; but that bodies should mutually act upon each other at a distance, and through an immense vacuum, seems at first sight altogether impossible. If the planets are moved by the forces of gravitation and projection, they must necessarily move *in vacuo*; for the continual resistance of even the rarest medium would in time overcome the force of the greatest impetus: but if they move *in vacuo*, how can they be attracted by the sun or by one another? It is a self-evident truth, that nothing can act but where it is present, either immediately or mediately; because every thing which operates upon another, must perform that operation either by its own immediate agency or by means of some instrument. The sun and planets are not in contact; nor, if the motion of these bodies be *in vacuo*, can any thing material pass as an instrument from the one to the other. We know indeed by experience, that every particle of unorganized matter within our reach has a tendency to move towards the centre of the earth; and we are intuitively certain, that such a tendency must have some cause; but when we infer that cause to be a power of attraction inherent in all matter, which mutually acts upon bodies at a distance, drawing them towards each other, we talk a language which is perfectly unintelligible (s). Nay more, we may venture to affirm that such an inference is contrary to fact. The particles of every elastic fluid fly *from* each other; the flame of a fire darts *upwards* with a velocity for which the weight of the circumambient air cannot account; and the motion of the particles of a plant when growing, is so far from tending toward the *centre* of the earth, that when a flowerpot is inverted, every vegetable in it, as soon as it is arrived at a sufficient length, bends itself over the side of the pot, and grows with its top in the natural position.

197
The heavenly bodies cannot be moved by two forces impressed *ab extra*;

Sensible of the force of these arguments against the possibility

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to it, without which we have endeavoured to prove, that the heavenly bodies could not revolve round their respective centres in elliptical curves.

(s) A different opinion on this point is held by Professor Stewart in his *Elements of the Philosophy of the Human Mind*; a work of which the merit is such as to make it painful to us to differ in any important opinion from the ingenious author. We shall, however, claim the same liberty of dissenting occasionally from him that he has claimed of dissenting from Newton, Locke, Clarke, and Cudworth, from whom he differs widely in thinking it as easy to conceive how bodies can act upon each other at a distance, as how one body can communicate motion to another by impulse. "I allow (says he, p. 79.) that it is impossible to conceive in what manner one body acts upon another at a distance through a vacuum; but I cannot admit that it removes the difficulty, to suppose that the two bodies are in actual contact. That one body may be the efficient cause of the motion of another body placed at a distance from it, I do by no means assert; but only that we have as good reason to believe that this may be possible, as to believe that any one natural event is the efficient cause of another."

If by *efficient* cause be here meant the *first* and *original* cause of motion, we have the honour to agree with the learned professor; for we are persuaded, that body inanimated is not, in this sense of the word, the cause of motion either at hand or at a distance: but if he mean (and we think he must, because such was the meaning of Newton, from whom he professes to differ), that we can as easily conceive one body to be the instrumental cause of the motion of another from which it is distant, as we can conceive it to communicate motion by impulse, we cannot help thinking him greatly mistaken. We will not indeed affirm, with the writer whom he quotes, "that although the experiment had never been made, the communication of motion by impulse might have been predicted by reasoning *à priori*;" because we are not certain, that without some such experiment we should ever have acquired adequate notions of the solidity of matter: But if all corporeal substances be allowed to be solid and possessed of that negative power to which philosophers have given the name of *vis inertiæ*, we think it may be easily proved *à priori*, that a sufficient impulse of one hard body upon another *must* communicate *motion* to that other; for when the *vis inertiæ*, by which alone the one body is kept in its place, is less than the *vis impetus* with which the other rushes to take possession of that place, it is evident that the former body *must* give way to the latter, which it can do only by motion, otherwise the two bodies would occupy one and the same place, which is inconsistent with their solidity. But that a substance possessed of a *vis inertiæ* should make another substance possessed of the same negative power quit a place to which itself has no *tendency*, is to us not only *inconceivable*, but apparently impossible, as implying a direct contradiction.

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possibility of an attractive power in matter which operates at a distance, other philosophers have supposed that the heavenly bodies are moved in elliptical orbits by means of two forces originally impressed upon each planet, impelling it in different directions at the same time. But if the tendency of the planets towards the centre of the sun be of the same kind with that of heavy bodies towards the centre of the earth (and if there be such a tendency at all, we have no reason to suppose it different), it cannot possibly be the effect of impulse. A body impelled or projected *in vacuo* would continue to be moved with an equable velocity, neither accelerated nor retarded as it approached the object towards which it was directed; but the velocity of a body tending towards the centre of the earth is continually accelerated: and as we cannot doubt but that the same thing takes place in the motion of a body tending towards the centre of the sun, that motion cannot be the effect of impulse or projection.

198 nor by the agency of any material fluid.

Some of the Newtonians therefore have supposed, "That all kinds of attraction consist in fine imperceptible particles or invisible effluvia, which proceed from every point in the surface of the attracting body, in all right-lined directions every way; which in their progress lighting on other bodies, urge and solicit them towards the superior attracting body; and therefore (say they) the force or intensity of the attracting power in general must always decrease as the squares of the distances increase." The inference is fairly drawn from the fact, provided the fact itself were real or possible: but it is obvious, that if fine imperceptible particles or invisible effluvia were thus issued from every point in the surface of the sun, the earth and other planets could not move *in vacuo;* and therefore the projectile motion would in time be stopped by the resistance of this powerful medium. Besides, is it not altogether inconceivable, nay impossible, that particles issuing *from* the sun should draw the planets *towards* that centre? would they not rather of necessity drive them to a greater distance? To say, that after they have reached the planets, they change their motion and return to the place whence they set out, is to endue them with the powers of intelligence and will, and to transform them from passive matter to active mind.

These difficulties in the theories of attraction and impulse have set philosophers upon fabricating numberless hypotheses: and Sir Isaac Newton himself, who never considered gravitation as any thing more than an effect, conjectured that there might be a very subtile fluid or ether pervading all bodies, and producing not only the motion of the planets, and the fall of heavy bodies to the earth, but even the mechanical part of muscular motion and sensation. Others (T) again have supposed fire, or light, or the electric fluid, to be the universal agent; and some few (U) have acknowledged, that nothing is sufficient to produce the phenomena but the immediate agency of mind.

With respect to the interposition of any material fluid, whether ether, fire, light, or electricity, it is sufficient to say that it does not remove any one difficulty which encumbers the theory of innate attraction. All these fluids are elastic; and of course the particles of which they are composed are distant from each other. Whatever motion, therefore, we may suppose to be given to one particle or set of particles, the question still recurs, How is it communicated from them to others? If one body can act upon another at the distance of the ten-thousandth part of an inch, we can perceive nothing to hinder its action from extending to the distance of ten thousand millions of miles. In the one case as well as the other, the body is acting where it is not present; and if that be admitted to be possible, all our notions of action are subverted, and it is vain to reason about the cause of any phenomenon in nature.

199 The hyp thesis of Plato, Ar stotle, ar Cudworth

This theory of the intermediate agency of a subtile fluid differs not essentially from the vortices of Des Cartes; which appeared so very absurd to Cudworth, that with a boldness becoming a man of the first genius and learning, he rejected it, and adopted the plastic nature of Plato, Aristotle, and other Greek philosophers. That incomparable scholar observes, that matter, being purely passive, the motion of the heavenly bodies, the growth of vegetables, and even the formation of animal bodies, must be the effect either of the immediate agency of God, or the agency of a *plastic nature* used as an instrument by Divine Wisdom. That they are not the effect of God's immediate agency, he thinks obvious from several circumstances. In the first place, They are performed slowly and by degrees, which is not suitable to our notions of the agency of almighty Power. Secondly, Many blunders are committed in the operations of nature, such as the formation of monsters, &c. which could never be were things formed by the immediate hand of God. He is therefore of opinion, that after the creation of matter, God employed an inferior agent to give it motion and form, and to carry on all those operations which have been continued in it since the beginning of the world. This agent he calls *plastic nature;* and considers it as a being incorporeal, which penetrates the most solid substance, and, in a manner which he pretends not to explain otherwise than by analogy, actuates the universe. He does not look upon it as a being endued with perception, consciousness, or intelligence; but merely as an instrument which acts under Divine Wisdom according to certain laws. He compares it to art embodied; and quoting from Aristotle, says, Ει ενην εν τω ξυλω ἡ ναυπηγικη ὁμοιως αν τη φυσει εποιει. *If the art of the shipwright were in the timber itself, operatively and effectual ly, it would there act just as nature doth.* He calls it a certain lower life than the animal, which acts regularly and artificially for ends of which it knows nothing. It may be, he says, either a lower faculty of some conscious soul, or else an inferior kind of life or soul by itself, but depending in either case upon a higher intellect. He is aware with what difficulty such a principle will be admitted by those philosophers who have divided all being into such as is extended and such as is cogitative: but he thinks this division improper. He would divide

(T) The several followers of Mr Hutchinson.
(U) Cudworth, Berkeley, and the author of Ancient Metaphysics.

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divide beings into those which are solid and extended, and those which have life or internal energy. Those beings which have life or internal energy he would again divide into such as act with consciousness, and such as act without it: the latter of which is this plastic life of nature. To prove that such an instrument is possible, or that a being may be capable of operating for ends of which it knows nothing, he instances *bees* and other animals, who are impelled by *instinct* to do many things necessary to their own preservation, without having the least notion of the purpose for which they work. (See INSTINCT). He observes, that there is an essential difference between reason and instinct, though they are both the attributes of mind or incorporeal substance: and that therefore, as we know of two kinds of mind differing so widely, there is nothing to hinder us from inferring a third, with powers differing as much from instinct as instinct differs from reason. Mankind are *conscious* of their own operations, *know* for what *purpose* they generally act, and can by the power of *reflection* take a *retrospective* view of their actions and thoughts, making as it were the mind its own object. Brutes are *conscious* of their own operations, but they are ignorant of the *purposes* for which they operate, and altogether *incapable* of *reflecting* either upon their past conduct or past thoughts. Between their intellectual powers and those of man, there is a much greater difference than there is between them and a plastic nature, which acts as an instrument of Divine Wisdom without any consciousness of its own operations. Aristotle, from whom principally the learned author takes his notion of this plastic nature, compares it, with respect to the Divine Wisdom which directs and superintends its operations, to a mere builder or mechanic working under an architect, for a purpose of which the mechanic himself knows nothing. The words of the Stagyrite are: *Τους αρχιτεκτονας περι ἑκαστον τιμιωτερους και μαλλον ειδεναι νομιζομεν των χειροτεχνων, και σοφωτερους ὁτι τας αιτιας των ποιουμενων ισασιν οἱ δ' ὡσπερ και των αψυχων ενια, ποιει μεν, ουκ ειδοτα δε ποιει, ὁιον καιει το πυρ· τα μεν ουν αψυχα φυσει τινι ποιειν τουτων ἑκαστον τους δε χειροτεχνας δι εθος* †. "We account the architects in every thing more honourable than the mere workmen, because they understand the reason of the things done; whereas the other, as some inanimate things, only work, not knowing what they do, just as the fire burns: the difference between them being only this, that inanimate things act by a certain nature in them, but the workman by habit."

† leta- ys. lib. i.). i.

200 wn to possible.

Still further to prove that a being may be endowed with some vital energy of a subordinate kind, and yet be destitute of consciousness and perception, the learned author observes, that there is no reason to think that the souls of men in sound sleep, lethargies, or apoplexies, are conscious of any thing; and still less, if possible, to suppose that the souls of embryos in the womb are from the very first moment of their arrival there intelligent and conscious beings: neither can we say, how we come to be so differently affected in our souls by the different motions made upon our bodies, nor are we conscious always of those energies by which we impress fantastic ideas on the imagination. But if it be possible for the souls of men to be for one instant void of consciousness and intelligence, it follows, that consciousness is not absolutely necessary to those energies and motions by which life is preserved. To this it may be added, upon the best authority †, "that where animal or vegetable life is concerned, there is in every case a different relation between the cause and effect, and seemingly depending upon the concurrence or influence of some farther principle of change in the subject, than what subsists in inanimate matter, or in the causes and effects that are the objects of mechanical and chemical philosophy." Now to this principle of vegetable life, without which, in a seed or in a plant, vegetation will neither begin nor continue, though light, heat, air, earth, and water, should concur in the utmost perfection, Cudworth expressly compares his plastic nature in the universe. It is so far (says he) from being the first or highest life, that it is indeed the last and lowest of all lives, being really the same thing with the vegetative.

† *Gregory's Philosophical and Literary Essays.*

201 Arguments for its truth: but

These arguments, if the phenomena of elective attractions in chemistry be added to them, demonstrate, we think, the *possibility* of such a principle: and to those who are inclined to affirm that no such thing can exist, because, according to the description of it given by Cudworth and the ancients, it is neither body nor spirit in the proper sense of the words; we beg leave to ask, in the words of Locke, "who told them that there is and can be nothing but solid beings which cannot think, and thinking beings that are not extended? which is all that they mean by the terms body and spirit." All the Greek philosophers who were not materialists, and even the inspired writers of the Old and New Testaments, constantly distinguish between the *spirit* and the *soul* of a man, calling the former sometimes *νους*, and sometimes *πνευμα*, and the latter *ψυχη*; and St Paul, who before he was a Christian, was learned in philosophy, describes the constituent parts of man as three, *πνευμα*, *ψυχη*, *σωμα*, *spirit*, *soul*, and *body*. This distinction, setting aside the *authority* with which it comes to us, seems to be well founded; for there are many operations carried on in the human body without any conscious exertion of ours, and which yet cannot be accounted for by the laws of mechanism. Of these, Cudworth instances the motion of the diaphragm and other muscles which cause respiration, and the systole and diastole of the heart; neither of which, he thinks, can be the effect of mere mechanism. But, as we are not conscious of any energy of soul from which they proceed, even while we are awake, and still less, if possible, while we are asleep; he attributes them, not to the intellect or rational mind, but to this inferior vital principle called *ψυχη* (v); which, in his opinion, acts the

(v) The existence of this plastic nature was warmly debated between Monsieur Le Clerc and Monsieur Bayle. Mosheim, who was inclined himself to admit such a principle, gives the following view of Le Clerc's sentiments from *Bibliotheque Choisie*, tom. ii. p. 113. "Respiratio, inquit, et motus cordis, actiones sunt, quorum nihil ad animam pertinet. Interim mechanice eas fieri, nullo modo probabile est. In voluntariis

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the same part in the system of the human body which the plastic nature acts in the system of the world.—To make the resemblance more striking, he observes, that even the voluntary motion of our limbs, though it proceeds ultimately from an energy of will, seems to be the effect of that energy employing some *instrument* which pervades the sinews, nerves, and muscles of the body; and if the human spirit or πνευμα employ the instrumentality of a plastic nature or ψυχη in moving the small machine of the body, it seems to be far from incredible that the Divine Wisdom should employ the instrumentality of a plastic nature in moving the great machine of the universe.

202 Whether it be true or not, the motions of the heavenly bodies are carried on by the constant agency of something incorporeal.

But we need not insist further on the *possibility* of such an instrument. Whatever may be thought of the arguments of Cudworth, of which some are, to say the least of them, plausible, though others appear to us to have very little strength, Dr Clarke has proved, with a force of reasoning not inferior to mathematical demonstration, that the motions of the heavenly bodies are carried on by the agency of something very different from matter, under every possible form. "For, not to say that, seeing matter is utterly incapable of obeying any *laws* in the proper sense of the word, the very original laws of motion themselves cannot continue to take place, but by something superior to matter, *continually* exerting on it a certain force or power according to such certain and determined laws: it is now evident beyond question, that the bodies of all *plants* and *animals* could not possibly have been formed by mere matter according to any general laws of motion. And not only so, but that most universal principle of *gravitation* itself, the spring of almost all the great and regular inanimate motions in the world, answering not at all the *surfaces* of bodies, by which alone they can act upon one another, but entirely to their *solid contents*, cannot possibly be the result of any motion originally impressed upon matter." For though it is true, that the most solid bodies with which we are acquainted are all very porous; and that, therefore a subtile material fluid might penetrate the bodies of the planets, and operate upon them with a force exerted internally; still it is self-evident, that the *greatest* quantities of such a fluid could not enter into those bodies which are *least* porous, and where the greatest force of *gravitation* resides: "and, therefore, this motion must of necessity be caused by something which penetrates the very *solid substance* of all bodies, and continually puts forth in them a force or power entirely different from that by which matter acts upon matter *." Which is, as the same able writer observes, an evident demonstration, not only of the world's being originally made by a supreme intelligent Cause; but moreover, that it depends every moment upon some superior Being, for the preservation of its frame; and that all the great motions in it are caused by some immaterial power *perpetually* and *actually* exerting itself every moment in every part of the corporeal universe. This preserving and governing power, whether it be the immediate power and action of the same Supreme Cause that created the world, or the action of some subordinate instruments appointed by him to direct and preside respectively over certain parts thereof, gives us equally in either way a very noble idea of Providence. We know with certainty, that *real* and *original power* can belong only to a being endowed with intelligence and will; and, therefore, if the existence of Cudworth's (W) plastic nature be admitted, (and we see not why it should be called

* *Eviden of Nat. a Revealed Religion.*

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tariis commotionibus nesciunt animi nostri, quid facto opus sit, ut membra commoveantur: imperant illi tantum. Est vero aliud nescio quid, quod fideliter, si modo organa recte sint affecta, mandata ejus exsequitur. Quidni igitur suspicemur, esse *naturam* in corpore nostro *viventem*, præter animam nostram, cujus sit animæ præceptis et jussis morem gerere? quamquam potentia ejus ita sit definita, ut obedire nequeat animo, nisi recte sese habeant organa. Eadem forte natura, corporis nostri motibus impulsa, animam edocet, quid factum sit, ut ille possit præcipere, quæ ad conservationem corporis necessaria judicat. Anima, pergit, sit hæc vera esse putes, similis erit domino, sibimet ipsi servire nescio, nec ulla facultate alia, quam imperandi et jubendi instructo. Hæc vero natura fictrix non dissimilis erit mancipii cui nihil eorum, quæ dominus meditatur, notum est, quodque nihil aliud facit, quam ut jussis pareat, et dominum de illis rebus admoneat, quæ ad salutem ipsius pertinent." Mosheim proceeds,—Si quis huic loco sic occurrat, Hæc ratione tria fingi in homine principia; respondet vir doctus: "Nullis constares argumentis, binis tantum hominem partibus constare. Eos, qui hominem ex binis tantum partibus component, nulla ratione explicare posse naturam conjunctionis animi et corporis, nisi ipsum Deum statuant cunctis actionibus hominum intervenire: hoc vero Divina Majestate prorsus indignum esse. Definitionem accuratam mediæ hujus naturæ postulantibus sese talem dare non posse definitionem respondet: Hoc unum sese scire: esse eam naturam interiori agendi virtute instructam, quæ ex se et animam et corpus afficere queat; naturam, quæ doceat animam quid rerum geratur in corpore; naturam denique, quæ animi mandatis, quorum tamen caussas nesciat, fideliter obtemperet." Reliqua, quæ illustrandæ hujus rei caussa Clericus affert, prætereo. Satis copiosa est in illis, quæ produximus, meditandi materia. *Mosheim. ed. Syst. Intellect.* p. 173.

Such a principle actuating the universe, if it be divested of intelligence, and considered as a second or inferior cause, under the direction of the Supreme, is acknowledged by a very able judge to be a rational hypothesis; and such, if properly pursued, would certainly open a most entertaining scene of natural philosophy.—See *Jones's Answer to an Essay on Spirit.*

(W) Besides Cudworth, we have mentioned Berkeley and the author of *Ancient Metaphysics*, as holding all motion to be an effect of the immediate agency of mind or incorporeal substance. The opinion of the last of these philosophers is not essentially different from Cudworth's; and therefore it is needless to quote from him: Berkeley was better acquainted with the principles of the Newtonian philosophy, as well as an abler mathematician,

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called in (X) question), it can be considered only as an instrument employed by Divine Wisdom, as a chissel or a saw is employed by the wisdom of the mechanic.

203 [This] theory [is no]t inconsistent with [th]e principles of [N]ewton.

Nor let it be imagined, that this ancient theory of motion is in any degree inconsistent with the mathematical principles of Sir Isaac Newton's astronomy, or with the calculations raised from those principles. Having founded his astronomy on analogy between the phenomena of projectile and planetary motions, he assigned the same or similar *forces* existing in nature as the efficient causes of both. And indeed, both in the act of deriving his *principles* from the projectile phenomena, and afterwards for the purpose of applying them to the planetary, it was necessary to analyze the elliptical motion of the heavenly bodies into a compound of two simple motions in right lines, produced by the action of these different forces; and this might also be useful for the purposes of teaching and demonstration, just as we find it necessary, in all parts of science, to separate what in nature is inseparable, for the convenience and assistance of the understanding. The planetary motions, however, are very probably simple and uncompounded, for no experiments can be tried in those distant regions; and the astronomy of Newton, which is only the application of his mathematical principles to their mensuration from their *analogy* to projectile motions, does not at all require that the forces of gravition and projection be assigned as their real existent causes (Y). It is sufficient for the

4 L 2 *analogy*

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matician, than either of these pupils of the ancients; and being likewise a man who on all subjects thought for himself, it may be worth while to lay before our readers a short abstract of his reasoning respecting the origin of motion. His words are: "Totum id quod novimus, cui nomen *corpus* indidimus, nihil in se continet quod motus principium seu causa efficiens esse possit. *Vis*, *gravitas*, *attractio*, et hujusmodi voces, utiles sunt ad ratiocinia et computationes de motu et corporibus motis; sed non ad intelligendam simplicem ipsius motus naturam, vel ad qualitates totidem distinctas designandas. Attractionem certe quod attinet, patet illam ab Newtono adhiberi, non tanquam qualitatem veram et physicam, sed solummodo ut hypothesin mathematicam. Quin et Leibnitius, nisum elementarem seu solicitationem ab impetu distinguens, fatetur illa entia non re ipsa inveniri in rerum natura, sed abstractione facienda esse. Similis ratio est compositionis et resolutionis virium quarumcunque directarum in quascunque obliquas, per diagonalem et latere parallelogrammi. Hæc mechanices et computationi inserviunt: sed aliud est computationi et demonstrationibus mathematicis inservire, aliud rerum naturam exhibere. Revera corpus æque perseverat in utrovis statu, vel motus vel quietis. Ista vero perseverantia non magis dicenda est actio corporis, quam existentia ejusdem actio diceretur. Cæterum resistentiam quam experimur in sistendo corpore moto, ejus actionem esse fingimus vana specie delusi. Revera enim ista resistentia quam sentimus, passio est in nobis, neque arguit corpus agere, sed nos pati: constat utique nos idem passuros fuisse, sive corpus illud a se moveatur, sive ab alio principio impellatur. Actio et reactio dicuntur esse in corporibus; nec incommode ad demonstrationes mechanicas. Sed cavendum, ne propterea supponamus virtutem aliquam realem, quæ motus causa sive principium sit, esse in iis. Etenim voces illæ eodem modo intelligendæ sunt ac vox *attractio*; et quemadmodum hac est hypothesis solummodo mathematica non autem qualitas physica; idem etiam de illis intelligi debet, et ob eandem rationem.

"Auferantur ex idea corporis extensio, soliditas, figura, remanebit nihil. Sed qualitates istæ sunt ad motum indifferentes, nec in se quidquam habent, quod motus principium dicit possit. Hoc ex ipsis ideis nostris perspicuum est. Si igitur voce *corpus* significatur id quod concipimus, plane constat inde non peti posse principium motus: pars scilicet nulla aut attributum illis causa efficiens vera est, quæ motum producat. Vocem autem proferre, et nihili concipere, id demum indignum esset philosopho.

"Præter res corporeas, alterum est genus rerum cogitantium: in iis autem potentiam inesse corpora movendi, propria experientia didicimus, quando quidem anima nostra pro lubitu possit ciere et sistere membrorum motus, quacunque tandem ratione id fiat. Hoc certe constat, corpora moveri ad nutum animæ, eamque proinde haud inepte dici posse principium motus; particulare quidem et subordinatum, quodque ipsum dependeat, a primo et universali principio.

"Ex dictis manifestum est eos qui vim activam, actionem motus principium, in corporibus revera inesse affirmant, sententiam nulla experientia fundatam amplecti, eamque terminis obscuris et generalibus adstruere nec quid sibi velint satis intelligere. E contrario, qui mentem esse principium motus volunt, sententiam propria experientia munitam preferunt, hominumque omni ævo doctissimorum suffragiis comprobatam.

"Primus Anaxagoras τον νουν introduxit, qui motum inerti materiæ imprimeret: quam quidem sententiam probat etiam Aristoteles, pluribusque confirmat, aperte pronuncians primum movens esse immobile, indivisibile, et nullum habens magnitudinem. Dicere autem, omne motivum esse mobile, recte animadvertit idem esse ac siquis dicerit, omne ædificativum esse ædificabile. Plato insuper in Timæo tradit machinam hanc corpoream, seu mundum visibilem, agitari et animari a mente, quæ sensum omnem fugiat. Et Newtonus passim nec obscure inuit, non solummodo motum ab initio a Numine profectum esse, verum adhuc systema mundanum ab eodem actu moveri. Hoc sacris literis consonum est: hoc scholasticorum calcula comprobatur."

De Motu, passim.

(X) This we say upon the received opinion, that there are things wholly incorporeal. The truth of the opinion itself will be considered in a subsequent chapter.

(Y) Indeed Sir Isaac himself is very far from positively assigning them as the *real* causes of the phenomena. The purpose for which they were introduced into his philosophy he clearly explains in the following words: "Eadem ratione qua projectile vi gravitatis in orbem flecti posset et terram totam circumire, potest et luna,

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Of Number.

analogy, on which the whole philosophy is founded, that the phenomena of motion are known from experiments and observations to be the *same* in *both* instances; that the *principles* or *general laws* mathematically established from the *forces* of the *one* are transferred to the *phenomena* of the *other*; and that the proofs and operations deduced from these principles in the latter case, are confirmed by *facts* and *experience*, the first and final test of truth *.

* *Tatham's Chart and Scale of Truth.*

Chap. VI. *Of* Number.

204 Unity, as an idea, cannot be abstracted from every individual.

"Amongst all the ideas that we have, as there is none (says Mr Locke†) suggested to the mind by more ways, so there is none more simple, than that of unity or *one*. It has no shadow of variety or composition in it. Every object our senses are employed about, every idea in our understandings, every thought of our minds, brings this idea along with it: and therefore it is the most intimate to our thoughts, as well as it is, in its agreement to all other things, the most universal idea we have; or number applies itself to men, angels, actions, thoughts, every thing that either doth exist or can be imagined." He seems likewise to be of opinion that we have the idea of *unity* before that of *many*; and that it is by repeating the simple idea of unity in our own minds that we come by the *complex ideas* of *two*, *three*, &c. In this opinion he is joined by Pere Buffier *; who observes that it is impossible to explain the nature of *unity*, because it is the most simple idea, and that which perhaps *first* occurred to the mind.

† *Essay*, book ii. chap. xvi.

* *First Truths.*

205 That *unity* is a simple idea, must be granted; but it certainly did not first occur to the mind, nor can it be abstracted from all individuals, and apprehended in Locke's sense of the word as a *general idea*. Let any man look into his own mind, and then say whether he has a general idea of *one* or *unity* as abstracted from every individual object mental and corporeal. In particular, when he thinks he has completely abstracted it from body and mind, sensations, ideas, actions, and passions, &c. let him be sure, before he pronounce it a general *abstract* idea, that he is not all the while contemplating the idea of its *name*, or of that numerical *figure*, by which it is marked in the operations of arithmetic. Both these ideas are in themselves particular; and become general in their import, only as representing every individual object to which unity is in any sense applicable. But in the chapter *of Abstraction*, we have said enough to convince every person capable of conviction that they are used as signs for whole classes of objets.

Instead of being an abstract general idea, *unity*, as the basis of number, is in fact nothing but a mere *relation*, which cannot be conceived without the related objects; and so far is it from being the *first* idea that occurred to the mind, that it is certainly the result of a comparison, made by the intellect, of two or more objects. The ideas which first occur to the mind are, beyond all doubt, those which are called *ideas of sensation*; and many such ideas every child receives before he is capable of comparing objects and forming to himself notions of number. *Unity*, or the idea of *one*, is indeed the element of the science of *arithmetic*, just as a mathematical *point* is the element of the science of *geometry*; but accurate notions of these elements are, in the progress of knowledge, subsequent to ideas of *many* and of *surfaces*. There is reason to believe that persons totally illiterate have no notion at all of *mathematical points*; and we think it possible to conceive an intelligent and conscious being in such a situation as that he could not acquire a notion of *unity* or *one*. Were a child never to see or feel two objects of the *same kind*, we doubt if he would think of numbering them, or of making such a comparison of the one with the other as would suggest to his mind the relations of *one* and *two*; for these relations imply both a sameness and a difference of the objects beyond the power of a child to ascertain. The difference indeed would be perceptible to the senses, but the senses would perceive no sameness or agreement. A guinea, a shilling, and a ball of lead, impress upon the mind different sensations; and therefore a child undoubtedly distinguishes these objects from one another: but what could make him derive from this his first idea of the relation of number? A guinea, a shilling, and a ball of lead, are not *one*, *two*, *three*, in any sense which a child can comprehend. To be convinced of this, let any man throw a guinea, a shilling, and a ball of lead upon a table, and ask a *clown* what is their number. From being accustomed to retail the *names* of number as signs, without affixing to them any idea of the things signified, he will probably answer with quickness *three*, or perhaps *one*, *two*, *three*: but if he be further asked in what *respect* they are *one*, *two*, *three*, we believe his answer will not be so ready: They are not *one*, *two*, *three guineas*, or *shillings*, or *balls of lead*. A philosopher knows them to be three pieces of the same first matter under different forms, and can therefore apply to them the relation of number with truth and propriety; but of the first matter a *clown* is entirely ignorant, and of course cannot call them *one*, *two*, *three*, in any sense which is at once true and to him intelligible.

208 Unity, a particular relation.

To make it still more evident, that it is only by comparing together things of the *same kind* that our *first* ideas of unity and number are formed, let us suppose no created being to have hitherto existed except the animated and intelligent globe mentioned in the last chapter, and we think it will be granted that such a being in solitude could never acquire the idea of *unity*. Let

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vel vi gravitatis, *si modo gravis sit*, vel alia quacunque vi qua in terram urgeatur, retrahi semper a cursu rectilineo terram versus et in orbem suum flecti: et absque tali vi luna in orbe suo retineri non potest. Hæc vis, si *justo minor* esset, non satis flecteret lunam a cursu rectilineo: si *justo major*, plus satis flecteret, ac de orbe terram versus deduceret. Requiritur quippe ut sit *justæ magnitudinis*: et mathematicorum est invenire vim, qua corpus in dato quovis orbe data cum velocitate accurate retineri possit; et vicissim invenire viam curvilineam, in quam corpus e dato quovis loco data cum velocitate egressum data vi flectatur."——*Principia Mathem.* Def. V.

Of [Num]ber.

Let us next suppose a *cubical* body to be created and exhibited to the senses of this spherical man; the consequence would be a *sensation* or feeling entirely new: but that feeling would not be of *unity*; for, as the author of *Ancient Metaphysics* has somewhere well observed, unity is no object of sensation. The sensation would be of colour, hardness, softness, roughness or smoothness, &c. for beyond these the empire of the senses does not reach. Again, Let another body be created of a colour and figure totally different from the colour and figure of the cube, and the spherical man would then experience new sensations having no agreement with those which he had formerly felt. These different kinds of sensations might be compared together; but the result of the comparison would not be the ideas which are denoted by the words *one* and *two*, but merely that which is expressed by *difference* or *dissimilarity*. Were another cube, however, of exactly the same size and colour with the former to be brought into existence, and both to be at once presented to the view of the spherical man, the rudiments of the idea of number would then be generated in his mind, because he could not but perceive the cubes to be in one respect different and in another the same; different as being distinct from each other, and agreeing in their effects upon the organs of sensation.

[20]7 must made pro- in ing s ac- ng to ra and es be- they ired notion umber.

It appears, therefore, that mankind must have made some progress in classing things according to their genera and species, before they acquired any correct ideas of the relation of number, or thought of using numerical names or figures as general and discriminating signs: for we say *one*, *two*, *three*, &c. only with respect to the species or genus of which each of the things denoted by these numbers is an individual; and if there be any thing which has no genus or species, neither number nor unity can, in the original sense of the words, be predicated of it (z). We say indeed, that there is *one* God; but perhaps we do not always attend to the meaning of the expression. Language was formed to answer the common purposes of life; and those purposes are best answered by denoting individuals by the name of the species or genus to which they belong: but *God* belongs to no species or genus, unless he be said improperly (A) to be of the universal genus of *Being*; and therefore, the true meaning of the word *one*, when joined to the verb *is*, and transferred from the creature to the Creator, in such a sentence as—"there *is one* God"—seems to be nothing more than an affirmation that God exists, and that to him the relation of number cannot be applied. In a word, *unity* and *number* are merely relations between the individuals of the same species or genus of being; and men acquire ideas of these relations at the same time and by the same means that they are led to class things into species and genera. As to the processes of addition and subtraction, and the various purposes to which number is applied, these things belong to the science of arithmetic, and fall not under the province of the metaphysician, whose sole object is to ascertain the real nature and causes of things. It may, however, be worth while to observe, that Locke, whose notions of number seem to have been different from ours, owns, that a man can hardly have any ideas of numbers of which his language does not furnish him with names. But if units were either real things, or even positive ideas, we see not how *names* could be necessary to their existence; whereas, if they be nothing more than mere relations, it is obvious that they cannot be conceived but as relative either to beings actually existing, or to names which are the signs of actual beings.

Chap. VII. *Of* Time.

208 Time, a mode of duration in contradistinction to eternity.

When St Augustine was asked what time is? he replied, "*Si non roges, intelligo.*" An answer from which it may be inferred, that he thought the nature of *time* could not be explained by a logical definition. *Time* and *eternity* are commonly considered as the two modes of *duration*; and if duration be taken in what Locke thinks its true and original sense, to denote permanence of existence, with a kind of resistance to any destructive force, the distinction seems to be sufficiently proper. It is indeed the best that we can make or comprehend; for *duration*, *time*, and *eternity*, are subjects which have perplexed philosophical minds in all ages, and of which, if we have adequate notions, it is very difficult to express these notions in language. Instead of attempting it by previous definitions, the method in which the ancients generally began their inquiries, we shall pursue the better course of induction recommended by Lord Bacon, and endeavour to show by what means we acquire the notion of that mode of duration which is called *time* in contradistinction to

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(z) We are happy to find our notions on this subject confirmed by an authority so respectable as that of Professor Stewart. "Without the power of attending separately to things which our senses present to us in a state of union, we never (says this able writer) could have had any idea of *number*: for before we can consider different objects as forming a multitude, it is necessary that we should be able to apply to all of them one common name; or, in other words, that we should reduce them all to the same genus. The various objects, for example, animate and inanimate, which are at this moment before me, I may class and number in a variety of different ways, according to the view of them that I choose to take. I may reckon successively the number of sheep, of cows, of horses, of elms, of oaks, of beeches; or I may first reckon the number of animals, and then the number of trees; or, I may at once reckon the number of all the organized substances which my senses present to me. But whatever be the principles on which my classification proceeds, it is evident that the objects numbered together must be considered in those respects only in which they agree with each other; and that if I had no power of separating the combinations of sense, I could never have conceived them as forming a plurality." *Elements of the Philosophy of the Human Mind*, chap. iv.

(A) We say *improperly*, because beings which were *created* can have nothing in *common* with that Being which is *self-existent*, and upon whose *will* and *power* all other things depend.

to *eternity*. We begin with time; because we ourselves exist in it, and it is in some sense familiar to us. If we be able to trace our notions of this mode of duration to their source, we may then give a definition of it founded on fact and universal experience, and afterwards proceed to consider the other mode in conjunction with infinity, to which it is nearly allied.

It has been already observed (see N° 92 of this article), that every man, while awake, has a train of sensations and ideas constantly passing through his mind in such a manner, as that the one succeeds the other in a regular order. It is not possible, either, by detaining in the mind one idea to the exclusion of all others, to stop the course of this succession entirely; or, by hurrying some ideas off the stage, and calling others in their place, to quicken its progress beyond a certain degree. One man indeed has naturally a quicker succession of ideas than another; and all men can, by great exertions, accelerate or retard in a small degree the natural flow of their thoughts. A studious man lays hold, as it were of a particular idea, which he wishes to contemplate, and detains it in the imagination, to the exclusion of all others; a

209 Whilst the mind is occupied by one idea or notion, there is no perception of time; which

man of wit calls remote ideas into view with a rapidity of which a cool and phlegmatic reasoner can form no conception; and a forcible *sensation* takes full possession of the mind, to the exclusion of all *ideas* whatever. Whilst the attention is wholly occupied by one idea, or by one sensation, the mind has no notion whatever of time; and were it possible to detain such idea or sensation alone in the mind till the hand of a clock should move from the number of one hour to that of another, the hour, as marked on the dial-plate and measured by the motion of the hand, would appear but as one instant absolutely void of duration. For the truth of this assertion we appeal to the experience of our readers. Such of them as have ever been engaged in deep study must often have had their attention so fixed upon one object, that large portions of time, as measured by the clock, have passed away wholly unheeded; and every man who has seen a very striking and uncommon object, must remember, that when the sensation was first impressed upon his mind, all other objects, ideas, and notions, and among the rest the notion of time, were for a while excluded.

210 arises from comparing the succession of our ideas with the permanence of other objects.

No sensation, however, keeps possession of the whole mind after it has ceased to be new; nor can the most vigorous exertions long preserve any one idea from being driven off the stage by the succeeding train. Now this succession of ideas appearing and disappearing in their turns, is that which, when compared with the permanency of ourselves and other things, gives us our first and justest notion of time: for whilst we are thinking, or whilst a series of ideas is successively passing through our minds and vanishing, we know that we ourselves and the things around us exist; and this existence, or continuation of existence, commensurate with the train of our fleeting ideas, is what we call the *duration* of ourselves and the things around us.

We are aware that the first notions of time have been often said to be derived from *motion* as perceived by our senses in the objects around us. It is observed by Euclid, that "if there were no *motion*, there could be no sound, nor any sense of hearing." "He might have added (says the author of Ancient Metaphysics), nor any other perception of sense. Further, Without motion there would have been no visible world, nor generation or production of any kind here below; and, among other things, *time* could have had no existence." All this is certainly true; but that corporeal motion, though the original source of all our ideas, is not that which *immediately* suggests to us the notion of time, will be readily granted by him who considers that motion itself is perceived by us only when it excites or accompanies a constant succession of perceptions and ideas. Motion, when equable and very slow, such as that of the hour hand of a common watch, is not perceived by us in its course; nor can we discover that the thing has moved at all, till after we have been sensible of the lapse of a considerable portion of what is commonly called *time*; when we discover that the hand of the watch has changed its place with respect to other objects which we know to be fixed. The same is true of motion remarkably quick: "Let a cannon ball (says Locke) pass through a room, and in its way take with it any limb or fleshy parts of a man; it is as clear as any demonstration can be, that it must strike successively the two sides of the room; it is also evident that it must touch one part of the flesh first, and another after, and so in succession: and yet I believe nobody who ever felt the pain of such a shot, or heard the blow against the two distant walls, could perceive any succession either in the pain or sound of so swift a stroke."

Of these two phenomena a satisfactory account may be easily given; from which we think it will at the same time be apparent, that the succession of the train of ideas in the mind is the measure and standard of all other successions. We know that the energy of 211

The succession of ideas the measure of all other successions.

mind which reviews a train of sensible ideas is of the very same kind with that which attends to a series of passing sensations (See N° 68.); and therefore it is natural to suppose that we can pay attention to sensations and ideas passing with nearly equal velocities. But it has been shown, that every sensation remains in the mind or sensorium, for a very short space after the object which excited it is taken away: whence it follows, that a body communicating to the organs of sense a series of similar impressions succeeding each other with remarkable rapidity, cannot excite a train of similar and distinct sensations; because the effects of the first and second impressions not having vanished when those of the third and fourth arrive, the whole train of effects must necessarily coalesce into one uniform sensation. This reasoning is confirmed by experience. Similar sounds succeeding each other at considerable intervals, are all distinctly perceived; and if the motion be accelerated gradually, it may be carried to a great degree of velocity before the sounds be confounded and coalesce into one. "Mr Herschel having, by means of a clock, produced sounds or clicking noises, which succeeded each other with such rapidity that the intervals between them were, as far as could be judged, the smallest possible, found that he could evidently distinguish one hundred and sixty of them in a second of time; but beyond that he could by no effort of attention distinguish one sound from another. The same philosopher tried another experiment on visible sensations. By means of the same handle and work of the clock, he caused a wheel in it to turn till

Of Time.

till it acquired the velocity of once in a second. He continued to increase the velocity, and observed it while revolving at the rate of twenty times round in thirteen seconds, and could still distinguish the teeth and spaces from each other; whence it appears (by a computation given at length), that he had two hundred and forty-six distinct visible sensations generated by equable motion in a second of time. The teeth of the wheel, he owns, were not so far visible as to show their shape distinctly, much less could they have been counted: but he very plainly distinguished the circumference to be divided into teeth and spaces; and he supposes that the same division might still have been seen though the motion had been a little faster, as far perhaps as two turns in a second, equal to three hundred and twenty sensations *." The reason that the division could not be seen whilst the wheel moved more rapidly than twice round in a second of time, was doubtless the continuance of that agitation in the brain from which each sensation proceeded, until a new impression caused a new agitation which coalesced with the former and removed all distinction Hence it is plain, that no external succession can be perceived which moves with a greater velocity than that of which the internal train of sensations and ideas is capable. On the other hand, an external succession which moves with less rapidity than that to which the internal flow of ideas may be reduced, either has not sufficient force to generate sensations at all, or the successive impressions from which the sensations proceed follow one another at such distances as to permit the natural train of ideas to intervene between them, and thus destroy the perception of the succession entirely.

* [Wat]tson's Tr[eat]ise on Ti[me].

To us, therefore, it seems evident, that the constant and regular succession of ideas in the mind of a waking man, is the measure and standard of all other successions; of which, if any one either exceeds the pace of which our ideas are capable, or falls short of it, the sense of a constant and continued succession is lost, and we perceive it not but with certain intervals of rest between. So that it is not motion, but the constant train of ideas in our minds, that suggests to us our first notion of time; of which motion no otherwise gives us any conception, than as it causes in our minds a constant succession of sensations: and we have as clear a notion of time by attending to the train of ideas succeeding each other in our minds, as by a train of sensations excited by constant and perceptible motion.

That it is merely by comparing the permanent existence of things with the fleeting succession of ideas in our own minds that we acquire our notions of time, may perhaps be still more evident from the following narrative quoted by Dr Beattie †, from *L'Histoire de l'Academie Royale des Sciences pour l'année* 1719. "A nobleman of Lausanne, as he was giving orders to a servant, suddenly lost his speech and all his senses. Different remedies were tried without effect. At last, after some chirurgical operations, at the end of six months, during all which time he had appeared to be in a deep sleep or delirium, his speech and senses were suddenly restored. When he recovered, the servant to whom he had been giving orders when he was first seized with the distemper, happening to be in the room, he asked whether he had executed his commission, not being sensible, it seems, that any interval of time, except perhaps a very short one, had elapsed during his illness." If this story be true, here was a man, who, by the train of ideas vanishing at once from his mind, lost the perception of what was to others six months of time: and had all mankind been in his state, the same portion of time would have been irrecoverably lost even to the annals of chronology.

† [Ess]ay on Tr[ut]h.

We are aware of an objection to any inference which may be drawn respecting the present question from the case of this nobleman. It may be said that he had lost, together with the perception of time, the perception of every thing besides; and that, therefore, motion may still be the cause from which a waking man derives his notions of time. But in reply to this objection, we beg leave to ask, Whether if a ball had been put in motion on a table, and the nobleman had been told, that a body moved with the velocity of that ball would have been carried over so many thousand miles of distance during the time that he lay in a state of insensibility, he could from such information alone have formed any tolerable notion of the length of time in which he was insensible? He certainly could not, for want of a standard by which to measure the rapidity of the motion. He would, indeed, have known instantly that he had been insensible for a considerable length of time, because he had the evidence of former experience that a body carried by perceptible motion over a great extent of distance would have generated in his mind a vast train of successive sensations; but till he had attended this ball during part of its course, and compared with the permanency of other objects the series of sensations which it generated in his mind, he would not have been able to guess with any thing near to accuracy the length of time it would take to pass over a thousand miles.—The same insensibility of duration happens to every man in sound sleep. From having notions of time, such as they are, formed in our minds, we never indeed suppose, however soundly we have slept, that the moment at which we awake in the morning is contiguous to that in which we fell asleep at night. The reason is obvious; every man has been awake whilst others were sleeping, and has known by experience, that if they had been awake likewise a train of ideas would have passed through their minds which must have suggested to them the notions of time. Most men, too, have been frequently awake whole nights, and have thus acquired a notion of time as going on incessantly, whether perceived by them or not; and this motion being closely associated with our ideas of night and morning, we inevitably suppose a portion of time to have elapsed between them, though unperceived by us in our sleep. But were a man to sleep without dreaming from Sunday night till Tuesday morning, and then to awake at his usual hour as marked on the clock, there are numberless instances on record to convince us, that he would not of himself suppose, nor perhaps be very easily persuaded, that more than one night had elapsed between his falling asleep and the moment at which he awoke.

It being thus evident, that our notion of time is suggested by that comparison which we inevitably make of the existence of things permanent with the train

Of Time. train of ideas incessantly passing through our minds; we may now perhaps be able to answer the question, "What is time?" It must of necessity be one of three things, viz. either the ideal succession itself; a certain quality inherent in all objects; or merely the relation of coexistence between things that are permanent and the trains of fleeting ideas which succeed each other on the theatre of the imagination. It is not the first of these; for in every train of thought, the appearance of any one idea in the mind occupies no more of the extension of time, than a mathematical point occupies of the extension of distance. Ten thousand mathematical points added together would make no part of a line; and ten thousand ideas made to coalesce, if that were possible, would occupy no part of that mode of duration which is called *time*. A point is the boundary of a line, but no part of it: the appearance of an idea in the mind is instantaneous; and an instant is the boundary, but no part of time. Hence it follows, that were every thing instantaneous like ideas in a train, there could be no such thing as time, since nothing could be said to have in that sense of the word any duration. That time is not a quality inherent in all objects, is likewise plain; for we have seen, that were *ideas* as permanent as objects, the notion of time could never have been acquired. Succession, though it does not itself constitute time, is essential to its existence; and were all motion to cease, and the attention of men to be immoveably fixed upon one invariable object or cluster of objects, *time* would cease likewise. It remains, therefore, that time can be nothing else than the relation of coexistence apprehended between things that are permanent and those trains of fleeting ideas which incessantly succeed each other on the theatre of the imagination. Thus whilst a man is steadily looking at one object, which, from its being common, does not occupy his whole mind, he may be conscious of a thousand ideas starting up in his imagination, and each in its turn vanishing the instant in which it appeared. Every one of these ideas had an existence as well as the object at which he is looking; but the existence of each of them was instantaneous and in succession, while the existence of the external object is permanent. The object, therefore, as contrasted with a train of ideas, is said to endure or to exist in time, whilst each idea is destitute of duration, and exists in no time.

212 Time a mere relation of coexistence.

213 Objections answered.

To this theory some objections occur, which it will be incumbent upon us to obviate. It may be said, that though each idea considered by itself is instantaneous, and occupies no time; yet the whole train when taken together, without being compared with any thing external, is perceived to occupy a considerable portion of that mode of duration; and that, therefore, time itself must be something more than a mere relation between a fleeting succession of ideas and objects of more permanent existence. But how, we beg leave to ask, is the whole train perceived to occupy any portion of time? Is it not by being compared with our own existence? A man whilst a train of ideas is passing through his mind may be suddenly deprived of all his external senses, and then indeed it will be impossible for him to compare the fleeting existence of this internal succession with the more permanent existence of external things; but, whilst he thinks at all, he must be conscious of his *own* existence, and cannot avoid perceiving, that whilst his ideas pass in constant succession, each making an instantaneous appearance in his mind, he himself remains unchanged. Now, what is it that this perception suggests to the mind? Evidently nothing more than the relation of coexistence between a fleeting succession and a permanent object; for were it possible that the man could be deprived of memory as well as of his senses, and still have ideas succeeding each other in his mind, he would then think all objects equally fleeting; he would indeed be himself a mere succession of instantaneous distinct persons, and could have no notion whatever of time. His existence, though it should seem to endure half a century as estimated by others, must to himself appear to pass away like a flash of lightning.

It may be still further objected to our theory, that time is measured by motion; and that it seems very absurd to talk of measuring a relation, especially a mere *ideal* relation, by a real external thing. In answer to this objection, which at first sight appears formidable, we beg leave to observe, that all relations are equally ideal; and that yet many of them may be said to be measured by real external things, with as much propriety as time can be said to be measured by motion. When a man wishes to ascertain the relation of quantity which one body bears to another, though he knows that such a relation has no other than an ideal existence, and cannot be conceived but in conjunction with the related bodies, he applies to them successively some commom standard; and having discovered the relation which each bears to that, he compares the one relation with the other, and thus ascertains the relation sought. Just so it is with respect to motion measuring time. That which to each individual constitutes real time, is the relation of coexistence between the fleeting succession of his own ideas and other things of a more permanent nature. But a man has often occasion to ascertain the time of things external which fall not under the inspection of his senses; and in society all men have transactions with one another to be performed in some determinate portion of time, though there are not, perhaps, two men existing whose ordinary trains of thought flow with precisely the same rapidity. To remedy these inconveniences, it was necessary to invent some common standard, by means of which men might ascertain the duration of actions performed at a distance, and be able to keep appointments made with each other. The only standard proper for these purposes is such a constant and equable motion as has suggested a flux of perceptions common to all men in all ages and countries; and hence the motions of the heavenly bodies have been universally made use of for the common regulators of time. These motions, however, do not constitute real and natural time, any more than a foot or a yard applied to two distant bodies constitutes the relation of quantity which these bodies bear to each other. They are merely stated measures, to be differently applied according to the different purposes which we have in view.

Thus, if a man in Europe wishes to know what would to him have been the *real* and *natural* time of an action performed in the East Indies, he has only to be told that it was co-existent, we shall suppose, with

Time. with a diurnal revolution of the earth; and by comparing this common measure with his usual flow of thought, he can form some notion of the extent of that train of ideas, which, had he been present, would to him have been successively co-existent with the action in question. But when persons have an appointment to keep, this common measure of motion must be differently, or rather partially, applied. In such cases, it is no part of their intention to compare their own existence with that of the whole train of ideas which may pass in the mind of each; for the result of such a comparison, which alone constitutes true and natural time, would not be the same in perhaps any two men: but their purpose is, to compare their own permanent existence only with that train of sensations which shall be excited in the mind by the perceptible motion of the sun, or any other body fixed upon which moves equably; and such a train must consist of an equal number of instants in all men. Neither the sun, nor the hour hand of a common watch, moves with such apparent rapidity as to keep pace with the internal flow of thought of which the most phlegmatic man is conscious. That these bodies move at all, is known only by their visible change of place during the lapse of a considerable portion of real time; and as there is in their course a certain number of places distinctly marked, to which alone it is agreed that the attention is to be turned, it is impossible that of time so computed two men can have different notions. Such time, however, is but partial; and the method of ascertaining it, when compared with that by which we ascertain real time, has a striking resemblance to that by which we ascertain the relation of partial quantity between two distant bodies. When it is our purpose to ascertain the relation of real quantity which one body bears to another, we apply the common standard to each in every dimension of length, breadth, and depth; but when we have no other view than to ascertain the relation of length which the one bears to the other, we apply the common standard to each in that dimension only. Just so it is with regard to real and partial time. When an individual wishes to ascertain what would to him have been the duration of any action which he did not see performed, he applies the common standard to the existence of that action, and to the usual flow of his own thoughts: but when two men talk of the duration of any action, or agree to meet on such a day, they compare the existence of the action, or the distance intervening between the present moment and the day of meeting, only with that partial train of sensations which by the common standard is generated in an equal number, and in the same order, in the minds of both.

214 [Ti]me must [have] had a [begin]ning.

It will be said, that if time be nothing more than a mere relation subsisting between trains of ideas or other fleeting objects, and things of a more permanent existence; and if the universe had a beginning; either time must have had a beginning likewise, or the Deity cannot be immutable. We allow the force of the argument; but instead of an objection, we consider it as a confirmation of the truth of our theory. The Deity, who is immutable, exists not in time, but in eternity; and that these, though from the poverty of language they are both called modes of duration, are yet very different from each other, we shall endeavour to prove in the next chapter. Of Infinity and Eternity.

Chap. VIII. *Of* Infinity *and* Eternity.

215 Why we treat of infinity and eternity among the adjuncts of body.

As corporeal substance is certainly not infinite, and as the present material system has in itself every evidence of its not being eternal, it may seem strange, perhaps, to the reader, that we should treat of infinity and eternity among the adjuncts of body. But in modern metaphysics these words are used in a vague sense to denote the extent of space and time; and in this chapter it is our intention to do little more than ascertain their meaning, and to show, in opposition to some celebrated names, of what subjects they may not be predicated. There is a mathematical and a metaphysical infinity, which, though often confounded, ought to be kept distinct. In mathematics, extension is said to be divisible *ad infinitum*, and number is sometimes considered as infinite: but in metaphysics these modes of expression are extremely improper. A positive and metaphysical infinite is that which has no limits, and to which no addition can be made; but it is obvious that there is no number which may not be enlarged, nor any positive idea of extension which has not limits, and which may not be either increased or diminished. The infinity of the mathematician is termed *infinity of power*, and that of the metaphysician *absolute infinity*. The first consists in this, that a being, however great or small it be supposed, may still be conceived to possess more greatness or minuteness than we can form an idea of, even after the utmost stretch of human thought. Thus when it is said, that all extension as such is infinitely divisible, it is not meant that every extended substance contains an infinite number of *real parts*: for then the parts of an inch would be equal to those of a league: but the meaning is, that in ideal extension we can never reach the end of ideal division and subdivision. In like manner, when it is said that number is infinite, the meaning is not that any positive number is without limits, or the possibility of increase, but that we might go on for ever, adding unit to unit, without approaching nearer to the end of the process. If, therefore, the mathematician would speak properly, and without the affectation of paradox, he ought to say that all extension as such is *indefinitely* divisible, and that unit might be added to unit without end; but these phrases suggest notions very different from that of a metaphysical infinite, which is something positive to which nothing can be added (B).

216 Space and time supposed to be, the one infinite, and the other eternal:

That there is something positively infinite, has been very seldom questioned; but it has been warmly disputed among metaphysicians what subjects are infinite.

(B) 'Ου γαρ ὀυ μηδεν ἐξω αλλ ὀυ αει το ἐξω ἐσλι, τουλο απειρον ἐσλι. *Arist. Phys. Auscult.* lib. ix. cap. 9. page 492. tom. i. *Oper.*

Of Infinity and Eternity.

Dr Clarke and his adherents have contended that space and time are real things; that they are bodies of necessary existence; that the former impresses us with the idea of its infinity, and that the latter is positively eternal. "Time and space (says the doctor *) are the *sine qua non* of all other *things*, and of all other *ideas*. To suppose either of them *finite*, is an express *contradiction* in the idea itself. No man *does* or *can* possibly *imagine* either of them to be finite; but only either by *non-attention* or by *choice* he attends perhaps to *part* of his *idea*, and *forbears attending to* the remainder. They who suppose *space* to be nothing but a *relation between two bodies* are guilty of the absurdity of supposing that which is *nothing* to have *real qualities*: *For the space which is between two bodies* is always unalterably just what it was, and has the very same dimensions, quantity, and figure, whether *these* or any *other bodies* be there or any where else, or not at *all*. Just as *time* or *duration* is the same, whether you turn your *hour-glass* or no, or whether the sun moves or stands still, or whether there *was* or *was not any sun*, or any *material world* at all. To set *bounds* to space is to suppose it *bounded* by something which itself *takes up space*, and that is a *contradiction*; or else that it is *bounded by nothing*, which is another contradiction. To suppose space *removed*, *destroyed*, or *taken away*, amounts to the absurd supposition of removing a thing away *from itself*; that is, if in your *imagination* you *annihilate* the *whole of infinite space*, the whole of *infinite space* will still remain; and if you annihilate any *part* of it, *that part* will still *necessarily* remain, as appears by the unmoved situation of the *rest*; and to suppose it *divided* or *divisible* amounts to the same contradiction."

** Demonstration of the Being and Attributes of God, and Correspondence with a Gentleman of Gloucestershire.*

The absurdity of considering space as a real external thing has been already evinced in Chap. IV. p. 624. where it was shown how we acquire the notion, and what kind of notion it is. Space, as was there observed, may be conceived either as the mere absence and possibility of body; or as ideal extension, united to, and inhering in, an ideal substratum. Taken in the former sense, it is an object of pure intellect; in the latter, it is an *idea* or *form* in the imagination. That the absence of body or matter is the *sine qua non* of all other things, and all other ideas, Dr Clarke was not dis-

217 but improperly.

posed to affirm, when he made the divine substance to pervade every material atom in the universe: and to talk of the absence of body being infinite is a palpable contradiction, unless Berkeley's doctrine be true, that the material world has no existence. To say that the *possibility* of matter is infinite, is to use language which has no other meaning than that, however far the material world be on all sides extended, its extension may still be conceived greater and greater *ad infinitum*. This is a position which no philosopher ancient or modern has ever denied; but it is so far from implying that we have a positive idea of the infinity of the material world, or of any adjunct of the material world, that it is absolutely inconsistent with such infinity. Whatever is capable of perpetual increase must certainly have limits, and every new addition is the limit of that to which the addition was made.

218 Neither space nor

Taken in the second acceptation as an ideal extension united with an ideal *substratum*, space is so far from being infinite in any sense of the word, that we will venture to assert no man ever contemplated such a *form* in his own imagination, without conceiving it to be bounded. Of this, at least we are certain, that when we have attempted to frame a positive idea of pure space, it has not been in our power to divest that idea of limits. Those who can frame in their minds real and positive ideas wholly abstracted from every individual object, may indeed perform in this way many feats above our abilities; but as we possess no such powers of abstraction, every thing which we can call an idea is limited in the same manner that the object itself is limited from which the idea was derived.—Thus, the largest expansion that ever we beheld is the concave hemisphere; and when we try to form the largest positive idea of pure space, all that we can do is to figure to ourselves that concave empty of body. We may, indeed, suppose its diameter to be either a million or ten thousand millions of miles; and we may go on enlarging it *ad infinitum*: but when we return from this process of intellect to the contemplation of the ideal forms of the imagination, none of these forms appear to us larger or more extended than the hemisphere, which is the object of sense, and they all appear to be bounded, and bounded in the very same way.

With respect to the eternity of time, we think Dr Clarke equally mistaken as with respect to the infinity of space. Of time, indeed, we cannot, properly speaking, have any *idea* or mental *form*. Time, as we have seen, is a mere relation, and is in itself the creature of the mind which has no external *idiatum*. It is suggested, however, by the fleeting succession of our ideas, compared with the more permanent existence of other objects: and therefore succession is essential to it. But nothing which has parts, whether coexistent or in succession, can be positively infinite. For, "in an infinite series of successive generations of men, for instance, there will be several infinites that are parts of one another; and by consequence one greater than another: which (as has been well argued *) is an express contradiction, since the greater must necessarily bound the less, and exceed its limits by so much as it is greater than it; that is, must make it not infinite. Infinite generations contain an infinitely greater infinity of particular men. An infinite number of men must have twice as many hands, and ten times as many fingers, and so on. Infinite time has an infinity of ages; these a much greater infinity of years, days, hours, &c. Space likewise (according to Dr Clarke) has three dimensions, all infinite. It must therefore, contain an infinity of surfaces, an infinitely greater infinity of lines, and a still infinitely greater infinity of physical points. The case is the same in number itself, which, if we suppose it to contain an absolute infinity of thousands (and we may as well do that as imagine it to comprehend an infinity of units), it will contain ten times as many hundreds, fifty times as many scores, and so on. All this is only the *indefiniteness* of number, which we in vain attempt to turn into a positive infinite with which it is totally incompatible. For let us add *one* to any of these infinite series of generations, ages, lines, or numbers, which we know to be always in our power, and if it was absolutely infinite before, here is one more than infinite. If it only becomes infinite now, then one finite added to another finite makes infinity. If it be no larger after

219 time ca[n be] positive[ly] infinite; and wh[...]

** Dr L[aw's] Inquiry [in]to the i[deas] of Space, Time, Immensity and Eternity. See also the same author's translation of King['s] Origin of Evil.*

Of Infinity and Eternity.

ter the addition than it was before, then one part added to another adds nothing; all which are absurdities. The same will appear, if we subtract a part from this supposed absolute infinite, which may be done in any of the forementioned subjects, as well as in every thing which admits of parts, or may be taken in pieces by the mind."

220 The usual answer to the foregoing reasoning shown

To this kind of reasoning Dr Clarke replies as follows: "To endeavour to prove that there cannot possibly be any such thing as *infinite time* or *space*, from the impossibility of an addition of finite parts ever composing or exhausting an infinite; or from the imaginary inequality of the number of years, days, and hours, that would be contained in the one; or of the miles, yards, and feet, that would be contained in the other, is supposing infinites to be made up of numbers of finites; that is, it is supposing finite quantities to be *aliquot* or *constituent parts* of infinite, when indeed they are not so, but do all *equally*, whether *great* or *small*, whether *many* or *few*, bear the very same proportion to an infinite, as mathematical points do to a line, or lines to a superficies, or as moments do to time, that is, none at all. No given number or quantity can be any *aliquot* or *constituent* part of infinite, or be compared at all with it, or bear any kind of proportion to it, or be the foundation of any argument in any question concerning it."

If it be indeed true, and it is that for which we contend, that no given number or quantity can be any aliquot or constituent part of infinite, or be compared at all with it; then it undeniably follows, not that miles, yards, and feet, are no constituent parts of space; or years, days, and hours constituent parts of time; but that space and time cannot possibly be positive infinites. This, we say, follows undeniably: for nothing is more evident, than that all quantities of the same kind, from the largest to the least, bear a certain proportion to each other; and upon the supposition that space is a real extending thing, miles, yards, and feet are included in it, and bear to it the relation of parts to a whole. The same is true of time, days, and hours. To affirm (for no proof is offered), that all finite quantities, whether great or small, whether many or few, do equally bear the very same proportion to an infinite, as mathematical points do to a line, or as moments do to time, is plainly to beg the question—

221 ...e a petitio principii.

"that *space* considered as a real extended thing is *infinite*;" and to beg it, too, in opposition to the common sense and reason of mankind. Mathematical points we all know to be nothing real, but merely negations of extension; but supposing space to be something real and extended, can any man persuade himself that a mile or a million of miles of this space is likewise a mere negation of extension? With him who can bring himself to this persuasion, we pretend not to argue. He is possessed of faculties, whether true or false, of which we are destitute.

That finite quantities, whether great or small, do all equally bear the same proportion to an *infinite in power*, is indeed true; but it is no great discovery: for such an infinite, as we have seen, is nothing but the continued possibility of repeating the same mental process of addition or multiplication; and he who can go on for ever adding, in his own imagination, foot to foot, or hour to hour, will find it equally easy to add, in the same manner, league to league, or age to age. If he can perform the one operation, he must likewise have power to perform the other; and he cannot but perceive that it is as impossible to come to an end, of adding league to league, or age to age, as of adding foot to foot, or hour to hour; but then he must know that these leagues, feet, ages, and hours, are not real external things, but mere ideas and notions in his mind. If such powers of ideal multiplication and addition be what Dr Clarke means by the ideas of space and time, it is indeed a contradiction to suppose either of them limited; for that is to suppose our powers different from what we know them to be by consciousness and experience. But to confound *powers* with the *objects* of those powers, is certainly very inaccurate; and to suppose, because we can go on for ever adding one portion of ideal space or time to another, that therefore our ideas of space and time are in themselves positively infinite, is a contradiction: for to an idea positively infinite, it is obvious that nothing can be added. Either, therefore, space and time do not impress us with the ideas of their positive infinity; or we cannot have the power of adding league to league, and age to age, without end.

"But (says the doctor) to suppose space removed, destroyed, or taken wholly away, amounts to the absurd supposition of removing a thing from itself; that is, if in your imagination you remove the whole of space, the whole of space will still remain." True, every man has ideas of space treasured up in his imagination, which the sound of the very word space will at all times bring into his immediate view; and whilst he has such ideas, it is impossible that he should not have them: which is all the mystery of the matter, and amounts to nothing more than that a thing cannot be and not be at the same instant. When the doctor affirms, that if "you annihilate any part of space, that part will necessarily remain, as appears by the unmoved situation of the rest," we are not certain that we perfectly understand him. A man may surely think of a cubical inch without thinking of a foot or a yard; and he may suppose the inch taken away from the foot or the yard, and these ideal quantities so much lessened by the subtraction. But if the doctor be here again confounding the powers of the mind with the positive ideas of space, the sentence when explained will be seen to contain nothing to his purpose. Every man has the power of contemplating in idea millions of miles, and millions of ages, and of adding mile to mile, and age to age, without end; and if he try to deprive himself of any part of this power, or to fix a limit to the mental process of addition, he will find that in spite of himself his imagination will ramble beyond the limit assigned, and that he has attempted an impossibility. This, however, is so far from being a proof that his ideas of space and time are positively infinite, that, as we have already observed, it is a proof of the contrary.

222 Space and time are said to be the *sine qua non* of all other things; but

But (says this great man and his followers) "space and time are the *sine qua non* of all other things and all other ideas. The supposal of the existence of *any thing whatever* includes necessarily a *presupposition* of the existence of *space* and *time*;" and, therefore, if there be any thing infinite and eternal, space and time must likewise be so.

To

Of Infinity and Eternity.

To every corporeal substance, and every idea of such substance, space and time are indeed necessary: for every body has extension and duration; and every idea of a particular body, being nothing but a secondary perception in the imagination or memory, must have the same relation to imaginary extension, that the object from which it was derived has to extension which is real. Every idea, too, which remains in the imagination whilst a train of other ideas passes successively in view, or whilst external things are perceived to change, has real time. But will any man say that *consciousness*, our notion of *power*, our acts of *willing*, or even *tastes*, *sounds*, and *smells*, are extended, or that the supposal of their existence necessarily implies a presupposition of the existence of space? We acquire our ideas of extension and space by means of our senses of touch and sight; and we learn from experience, that things external and extended are the causes of our sensations of taste, sound, and smell. The effects are in our minds closely associated with the ideas of their causes; and it is not perhaps easy to think of a particular sound, taste, or smell, without at the same time thinking of the object by which it was first excited in the mind; but had we been originally formed with the powers of consciousness, thinking, and willing, and with no other senses than those of tasting, smelling, and hearing, it is obvious that we never could have had the idea of *space*; and therefore, that idea cannot possibly be necessary to the presupposition of every thing else. To consciousness, thinking, and willing, space is so far from being necessary, that we cannot perceive any the most distant relation between them. It is not more difficult to conceive a part greater than the whole, than it is to conceive an ell of *consciousness*, of *thought*, or of *will*; nor is it in the power of any man to make *space* and *sweetness* coalesce in his mind so as to form of the two simple ideas one complex conception. The very reverse is the case with respect to the objects of sight and touch. The idea of every thing which we see and handle necessarily coalesces in the mind with the idea or space, nor can we possibly separate the one from the other; but the things which we see and handle are neither infinite nor capable of infinity.

223 there are things which have no relation whatever to space, or

224 to time.

With respect to time, the same observations will be found to be just as with respect to space. Whatever is liable to change, exists in time and cannot be eternal; but if there be any being immutable, and who views at once all things which to us are past, present, and to come, the existence of that being is not commensurable with time. That such a being is possible no man can doubt, who reflects, that if we had one permanent idea invariably in the mind, we should never have acquired the *notion* of succession or of time; and that if there were *actually* no *change* in nature there could not possibly in nature be any such *thing as time*. Every man, therefore, who can conceive existence without change, must be convinced, that "the supposal of the existence of any thing whatever does *not* necessarily include the presupposition of the existence of time; and that there may be an eternity distinct from time, as well as an infinity distinct from space; nay, that nothing which is properly infinite and eternal can possibly occupy either space or time.

225 Infinity and eternity, what they are.

If it be asked, What kind of infinity and eternity they are which have no relation to space and time? Cudworth, treading in the footsteps of the ancients, has long ago answered, That they are "absolute perfection, and necessary existence. For (says he), *infinite understanding* and *knowledge* is nothing else but *perfect* knowledge, which hath in it no defect or mixture of ignorance, but knows whatsoever is knowable. In like manner, *infinite power* is nothing else but *perfect* power, which hath in it no defect or mixture of impotency—a power which can do every thing which is possible or conceivable. Lastly, *Infinity of duration*, or *eternity*, is really nothing else but *perfection*, as including in it *necessary existence* and *immutability*; so that it is a contradiction to suppose such a being to have had a beginning, to cease to be, or to suffer or be affected by any change whatever. And because infinity is perfection, therefore nothing which includes in its idea or essence any thing of *imperfection*, as every positive idea of number, corporeal magnitude, and successive duration, evidently does, can be truly and properly infinite *."

* *Intellectual System.*

It must indeed be confessed, that the idea of succession so insinuates itself into our usual ideas of existence, and is so closely connected with the existence of all finite beings, that we find it extremely difficult to imagine the eternal existence of God, any otherwise than as an eternally continued series or succession. Our constant conversation with material objects, and the associations thence arising, make it almost impossible for us to consider things abstracted from time and space; yet we have the evidence of experience and consciousness, that an idea may be conceived without relation to space and time, and that space and time cannot be made to coalesce with some of our notions. The same must be true with respect to infinity and eternity; for we have seen that neither space, time, nor any thing else which consists of parts, whether continuous or successive, can be supposed to be positively infinite, as the supposition implies the most palpable contradiction. But that there may be perfect power, perfect knowledge, and permanent invariable existence, is so far from implying any contradiction, that even we, whose faculties are so very narrow, can yet make some advances towards the conception of such perfections. Thus, every man of common understanding knows that some things are in themselves possible, and others impossible, to be performed by any power. Of these possibilities and impossibilities a philosopher knows more than an illiterate man; and one philosopher knows more than another. An intellect more perfect knows more of them than any man; and that intellect which knows them all must be absolutely perfect, and incapable of improvement, because it knows every thing which is to be known. The same is true of perfect power:—but we shall treat of real infinity and eternity more at large when we come to demonstrate the being and attributes of God. At present it is sufficient to have shown that nothing can be positively infinite but a being absolutely perfect; which never was not, which can produce all things possible and conceivable, and upon which all other things must depend.

PART

PART III. OF MINDS AND THEIR POWERS.

Chap. I. *Of* Mind *in* General.

THE science of metaphysics comprehends every thing, into the existence, nature, or causes of which any inquiry may be made. But all things of which we have any notion or idea may be divided into mind and body, with their various powers, qualities, and adjuncts. By body is meant that which is solid, extended, inert, and divisible; and its several adjuncts are space, motion, number, and time. The only mind with which we are *intimately* acquainted is our own; and we know that it is possessed of the powers of sensation, perception, retention, consciousness, reflection, reason, and will. These are totally different from extension, solidity, divisibility, and motion; and therefore it is proper to distinguish the being of which they are powers by another name than that of body.

226 Mind distinguished from body.

227 Probably kinds of different minds.

Of bodies there are various kinds possessing various sensible qualities; and from analogy it is reasonable to conclude, that there may be various classes of minds endowed with different kinds or degrees of power. For this indeed we have stronger evidence than that of analogy. Brute animals evidently possess the powers of perception and spontaneity with some degree of consciousness; but as they appear not to reflect upon their own conduct, or to have their actions influenced by motives, their minds are inferior to ours, though still perfectly distinct from mere extended, inert, and divisible substances. Mind, therefore, considered with respect to its powers, is evidently different from body considered with respect to its qualities. This is indeed a truth which has seldom if ever been controverted; but it has been long and warmly disputed, Whether mind and body be not both composed of the same first matter?

228 The absurd hypothesis of Hobbes respecting mind.

Hobbes supposed that every material atom is endowed with the faculty of sensation (c); but that for want of memory each sensation is momentaneous, being instantly and wholly effaced as soon as its cause is removed. Though this hypothesis is too absurd to require a formal and laboured confutation, it may not be improper to observe, that, if it were true, the hairs of a man's head would feel extreme pain when pinched by the hot iron of the hair-dresser; and that the nails of his fingers would be severely tortured when under the operation of the knife or the rasp.

229 Other hypotheses.

Others have supposed that each atom of matter has a *tendency towards* sensation and perception; and that when a sufficient number of these atoms are brought together in a certain order, the *united tendencies* produce the *actual* powers which distinguish mind from gross body. This supposition is if possible more absurd than that of Hobbes. Sensation and perception are of such a nature, that a mere *tendency towards* them is inconceivable. A thing must either be sensible and percipient, or insensible and inert: there is evidently no medium. Or if we could suppose each individual atom to have a *tendency* towards sensation, it would by no means follow that a number of such atoms brought together in any possible order would become one sentient, thinking, and active being. A number of bodies laid upon an inclined plane have each a *tendency* to roll downwards; but if the declivity of the plane be not such as that their separate tendencies may overcome the resistance opposed to each individual body by friction, the *united tendencies* of all the bodies when brought together will not be able to overpower the resistance of their united frictions. Just so is it with respect to sensation and perception: If the tendency of one atom cannot overcome one degree of inertness, the tendency of a thousand atoms will not overcome a thousand degrees of the same inertness. 230

Only two opinions at present on the subject.

We have just mentioned these absurd suppositions that our article might be complete: but it is proper to inform the reader, that, so far as we know, neither of them has for these many years been maintained by any philosopher of eminence either at home or abroad. The opinions on this subject, which at present divide the republic of letters, are two; and these alone are worthy of examination. One party maintains, That perception, memory, reason, and will, &c. are the powers of a being which must be immaterial and indivisible: The other alleges, That as we know nothing of these powers but from our own consciousness, and as we can trace them in ourselves to the brain and no farther, we have no reason to suppose that they are the powers of any substance distinct from matter. Both parties, however, distinguish that which in man is the subject of thought from his external organs of sense, and agree to call it by the name of *mind;* though the one considers it as composed of the same first matter with the dust of the ground; whilst the other believes it to have no property whatever in common with that matter.

Were we to adopt some of the ancient methods of philosophizing, this important question might be soon decided. A most respectable writer, who has laboured to restore the metaphysics of Plato and Aristotle, hopes to confute the materialists, by laying down what they must think arbitrary definitions of mind and matter, and then showing that the one is not the other. "In

(c) Scio fuisse philosophos quosdam, eosdemque *viros doctos*, qui corpora omnia sensu prædita esse sustinuerunt: *Nec video*, si natura sensionis in reactione sola collocaretur QUOMODO *refutari possint*. Sed etsi ex reactione etiam corporum aliorum, phantasma aliquod nasceretur; illud tamen, remoto objecto, statim cessaret. Nam nisi ad retinendum motum impressum, etiam remoto objecto, apta habeant organa, ut habent animalia; ita tantum sentient, ut nunquam sensisse se recordentur. Sensioni ergo, quæ vulgo ita appellatur, necessario adhæret memoria aliqua. *Hobbes's Physic*, cap. xxv. sect. 5.

Of Mind in general.

"In all the parts of the material world (says he) there is a perpetual *motion*: For the celestial bodies move constantly in one respect or another; and all here below is in a continual vicissitude of generation and corruption, which cannot be without *motion*. Now, where there is *motion*, there must be something that *moves*: What is *moved* I call *body*: what moves I call *mind*." From this definition he undertakes to prove, that mind must be immaterial. "That there is a relation between *moving* and *being moved* (says he) nobody can deny; and the relation is no other than that of *action* and *passion*. But the nature of relation is such, that it must necessarily be between two things at least; and it is further necessary, that the two things related should exist together. Hence, if there be that which *moves*, there must be a different thing that *is moved*; and wherever the one is, the other must necessarily be; so that nothing can move itself. This being established, I say that what *moves* must be either material or immaterial: for the one of these being the negation of the other, there can be no middle betwixt them; because a thing must necessarily *be*, or not *be*. If then it be immaterial, there is an end of the question: but if it be said to be material, then I say that it must be *moved* itself before it can move any thing else; for it is only in that way that body can move body. If then it must be first moved itself, but cannot itself move itself, what is it that moves itself? If it be answered, That it is another material mover, then I repeat the same question, to which the same answer must be given: and so we have an infinite series of *material movers*, without any beginning or *principle* of *motion*. Now this is absurd, and contradictory to this first principle of natural philosophy, admitted by all philosophers ancient and modern, That *nothing can be produced without a cause**.

* *Ancient Metaphysics.*

For the immateriality of the human mind, and of every being endowed with the powers of perception and thought, the learned writer has better arguments; but it is upon this chiefly that he rests his persuasion, that mind is the only *mover* in the universe. It is needless to observe, that in the very definitions and axioms upon which this reasoning is built, the thing to be proved is taken for granted: for if it be self-evident, that what *moves* is, in the author's sense of the word, *mind*, that what is *moved* is *body*, and that *nothing can move itself*, all reasoning on the subject is superfluous. This, however, is so far from being self-evident, that a materialist may reply, "every animal moves itself, and yet every animal is nothing more than a system of matter." This position, whether true or false, can neither be proved nor confuted by arguments *à priori* founded on general definitions. That animals move themselves, and that to the senses they appear to be nothing else than systems of matter, are facts which cannot be controverted. If we would know whether they have in them a principle of motion which is not material, we must submit to the laws of induction (see LOGIC); and by investigating the essential qualities of matter, endeavour to ascertain whether a material system can be rendered active. That we ourselves have active powers, we know by the most complete of all evidence, viz. consciousness of their energies; and it has been already shown, that such powers as we experience in ourselves cannot exist but in a subject possessed of will and understanding. The question therefore to be first decided between the materialists and immaterialists is, Whether the powers of consciousness, understanding, and will, can result from the particular organization of a system of matter? If they can, we have no reason to attribute them in man to any other source: If these powers appear necessarily to require an immaterial principle for their support, it will probably be granted, that an immaterial principle is the source of every power and every motion in the universe; and the doctrine of *mind*, in the strictest sense of the word, will be sufficiently established.

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231 The proper method of investigating the nature of mind.

CHAP. II. *Of the* SUBSTANCE *of the* HUMAN MIND.

232 Argument for the immateriality of the human mind.

THE most celebrated materialist of this or perhaps of any other age is Dr Priestley; who having in his own imagination divested matter of solidity, and reduced it to mere centres of attraction and repulsion, observes, that "if one *kind of substance* be capable of supporting all the known *properties* of man; that is, if those properties have nothing in them that is absolutely incompatible with one another; we shall be obliged to conclude (unless we openly violate the rules of philosophizing, which will not authorize us to *multiply causes* or kinds of substance *without necessity*), that no other kind of substance enters into his composition; the supposition being manifestly *unnecessary*, in order to account for any appearance whatever.—All the properties that have hitherto been attributed to matter, may be comprised under those of attraction and repulsion. Besides these, man is possessed of the powers of *sensation* or *perception*, and *thought*. But if, without giving the reins to our imaginations, we suffer ourselves to be guided in our inquiries by the simple rules of philosophizing above mentioned, we must necessarily conclude, that these powers also may belong to the same substance that has also the properties of attraction, repulsion, and *extension* (D), which I as well as others call by the name of *matter*. The reason of the conclusion is simply this, that the powers of sensation or perception and thought, as belonging to man, have never been found but in conjunction with a certain *organized system of matter*; and therefore that those powers necessarily exist in and depend upon such a system. This at least must be our conclusion, till it can be shown that these powers are incompatible with the

(D) When Dr Priestley mentions the *extension* of corporeal substance, it must be remembered that he does not mean the extension of any real thing possessed of an independent existence. The extension belongs wholly to the *sphere* or the *combination* of spheres of *attraction* and *repulsion*. The centre itself, which attracts and repels, he repeatedly affirms not to have the dimensions even of a physical point; and he sometimes seems to entertain a doubt whether it be any thing more than a mere relative notion.

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the other known properties of the same substance; and for this I see no sort of pretence."

This is what Dr Priestley calls the proper and direct proof that the sentient principle in man is the material substance of the brain; and he enforces it by the following observations: "Had we formed a judgment concerning the necessary seat of thought by the circumstances that *universally accompany it*, which is our rule in all other cases, we could not but have concluded that in man it is a property of the *nervous system*, or rather of the brain; because, as far as we can judge, the faculty of thinking, and a certain state of the brain, always accompany and correspond to one another; which is the very reason why we believe that any property is inherent in any substance whatever. There is no instance of any man retaining the faculty of thinking when his brain was destroyed; and whenever that faculty is impeded or injured, there is sufficient reason to believe that the brain is disordered in proportion: and therefore we are necessarily led to consider the latter as the seat of the former. Moreover, as the faculty of thinking in general ripens and comes to maturity with the body, it is also observed to decay with it; and if, in some cases, the mental faculties continue vigorous when the body in general is enfeebled, it is evidently because in those particular cases the *brain* is not much affected by the general cause of weakness. But, on the other hand, if the brain alone be affected, as by a blow on the head, by actual pressure within the skull, by sleep, or by inflammation, the mental faculties are universally affected in proportion. Likewise, As the mind is affected in consequence of the affections of the body and brain, so the body is liable to be reciprocally affected by the affections of the mind, as is evident in the visible effects of all strong passions, hope or fear, love or anger, joy or sorrow, exultation or despair. These are certainly irrefragable arguments, that it is properly no other *than one and the same thing* that is subject to these affections, and that they are necessarily dependent upon one another. In fact, there is just the same reason to conclude, that the powers of sensation and thought are the necessary result of a particular organization, as that sound is the necessary result of a particular concussion of the air. For in both cases equally the one constantly accompanies the other; and there is not in nature a stronger argument for a necessary connexion of any cause and any effect. To adopt an opinion different from this, is to form an hypothesis without a single fact to support it*."

Disquisitions on Matter and Spirit.

Though the ingenious author thinks, that if there be any foundation for the established rules of philosophizing, this reasoning ought to be conclusive, he yet subjoins, for the greater satisfaction of his readers, some additional arguments, or rather, as he says, distinct illustrations of the great argument. They are as follow:

1. "That the faculty of thinking necessarily depends, for its *exercise* at least, upon a stock of ideas, about which it is always conversant, will hardly be questioned by any person. But there is not a single idea of which the mind is possessed but what may be proved to have come to it from the bodily senses, or to have been consequent upon the perceptions of sense. The notion, therefore, of the *possibility* of thinking in man, without an organized body, is not only destitute of all evidence from actual appearances, but is directly contrary to them; and yet these appearances ought alone to guide the judgment of philosophers.

2. "The only reason why it has been so earnestly contended for, that there is some principle in man that is not material, is, that it might subsist, and be capable of sensation and action, when the body is dead. But if the mind was naturally so independent of the body, as to be capable of subsisting by itself, and even of appearing to more advantage, after the death of the body; it might be expected to discover some signs of its independence before death, and especially when the organs of the body were obstructed, so as to leave the soul more at liberty to exert itself; as in a state of *sleep* or *swooning*, which must resemble the state of death; in which it is pretended that the soul is most of all alive, most active, and vigorous. But judging by appearances, the reverse of all this is the case.

3. "If the mental principle was, in its own nature, immaterial and immortal, all its particular faculties would be so too; whereas we see that every faculty of the mind without exception is liable to be impaired, and even to become wholly extinct, before death. Since, therefore, all the faculties of the mind, separately taken, appear to be mortal, the substance or principle in which they exist must be pronounced to be mortal too.

4. "If the sentient principle in man be immaterial, it can have no *extension*; it can neither have length, breadth, nor thickness; and consequently every thing within it, or properly belonging to it, must be *simple* and *indivisible*. Let us now consider how this notion agrees with the phenomena of sensation and ideas. It will not be denied, but that sensations or ideas properly exist *in the soul*, because it could not otherwise retain them, so as to continue to perceive and think after its separation from the body. Now, whatever ideas are in themselves, they are evidently produced by external objects, and must therefore correspond to them; and since many of the objects or archetypes of ideas are divisible, it necessarily follows, that the ideas themselves are divisible also. But, how is it possible that a thing (be the nature of it what it may) that is *divisible*, should be contained in a substance, be the nature of *it* likewise what it may, that is *indivisible*? If the archetypes of ideas have extension, the ideas which are expressive of them, and are actually produced by them according to certain mechanical laws, must have extension likewise: and therefore the mind in which they exist, whether it be material or immaterial, must have extension also. But how any thing can have extension and yet be immaterial, without coinciding with our idea of mere empty *space*, I know not."

To the argument, which is here chiefly insisted on as being agreeable to the established rules of philosophizing, a very able reply has been made, which we shall give in the words of its elegant and spirited author. But before we attempt to dig up the foundation of the doctor's system, it may not be improper to demolish, if possible, the additional buttresses by which it is strengthened. An experienced general, before he storm a citadel which he knows to be strongly

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ly fortified and skilfully defended, will take care to raze every less important redoubt from which the enemy might annoy him in his rear.

233 Answered.

Because the faculty of thinking in general ripens, comes to maturity, and decays with the body, and the body on the other hand is affected by the affections of the mind, the doctor affirms that we have the same reason to conclude, that the powers of sensation and thought are the necessary result of a particular organization, as that sound is the necessary result of a particular concussion of the air. This argument is conclusive only upon the supposition that there is no *positive* evidence whatever of the immateriality of the being which is the subject of thought. If the other reasonings for the materiality or immateriality of the mind be of equal weight, this argument ought doubtless to turn the balance; but if there be the smallest preponderancy in behalf of the immaterialists, it is a mere begging of the question to attempt to counteract it by any inference which can be drawn from the mutual affections of the body and mind. If two such heterogeneous beings as an immaterial mind and an organized body can be supposed united in one person, they must necessarily affect each other; and to affirm on account of this reciprocal affection, that they are *one and the same*, is equally absurd as to say that an electrician and his apparatus are *one and the same*. Dr Priestley himself did not at first perform his electrical experiments with so much ease as after he had acquired facility by long practice, nor could he even yet perform them so neatly with a bad as with a good apparatus.

That which the doctor calls the first illustration of his argument might be admitted, and the force of the argument itself be consistently denied. Some kind of organized body may be necessary to the mind as an instrument without which it could not exert its faculties; but it would certainly be rash to infer that the mind must *therefore* be a system of matter. An anvil and a hammer are necessary to the exercise of the blacksmith's art; but what would be thought of him who should from this fact conclude, that the blacksmith himself must be a system of iron! This, therefore, instead of illustrating the great argument, seems to be wholly foreign from the question in debate; and it has in fact been admitted by Dr Price *, and thousands of others who reject the doctrine of materialism, as an impious absurdity. The second illustration, however, is more to the purpose; and as it is not new, we shall give it an old answer.

* *Correspondence with Dr Priestley.*

Why do not we perceive external objects in our *sleep* or in a *swoon*? "Because (says Mr Wollaston †), the *passages* are become impracticable, the *windows* shut, and the *nerves* being obstructed, or somehow rendered for the time useless, can transmit no information to it. Why, however, does it not reason and think about *something or other*? Because, all the *marks* by which things are remembered, being for the present choked up or disordered, the remembrance of those *objects* about which it is wont to employ itself, and even of the words (or other signs) in which it uses to reason, and to preserve the deductions and conclusions it makes, is all suspended at least for the time: and so its tables being covered, its books closed, and its tools locked up, the requisites for reasoning are wanting, and no subject offers itself to exercise its thoughts, it having yet had little or no opportunity to take in *higher objects* and more *refined matter* for contemplation. And, to conclude, if it be demanded, Why any one should imagine that the *soul* may think, perceive, act, *after death*, when it doth not do this in sleep, &c.? the answer is, Because those *enclosures* and *impediments* which occasioned the forementioned intermissions, and those great limitations under which it labours at all times, will be removed with its enlargement out of the body. When it shall in its *proper vehicle* be let go, and take its flight into the open fields of heaven, it will then be bare to the immediate impressions of objects: And why should not those impressions which affected the *nerves*, that moved and affected the vehicle and soul in it, *affect the vehicle immediately* when they are immediately made upon it, without the interposition of the nerves? The hand which feels an object at the end of a *staff*, may certainly be allowed to feel the same much better by *immediate contact* without the staff."

† *Religion of Nature Delineated.*

The opinion, that the soul is united to some fine vehicle, which dwells with it in the brain, and goes off with it at death, was not peculiar to Mr Wollaston. It was thought extremely probable by Dr Hartley, and shall be shown afterwards to have been a very ancient opinion; but we do not quote it at present as either well or ill founded, but only as sufficient, in conjunction with the reasoning of its author, to obviate the force of Dr Priestley's second illustration of his argument for the materiality of mind, provided the argument itself be not more powerful than any which the immaterialists can bring against it.

The doctor's third illustration we have already obviated, when we accounted for the mind and the body mutually affecting each other; and we might refer to Dr Price's answer (E) to the fourth, as being, in our opinion, a full confutation of it. But as that author's notions of *mind* and *ideas* differ in some respects from our own, we shall examine this objection to the doctrine of the immaterialists upon principles which we believe Dr Priestley more inclined to admit.

That the sentient principle in man, if it be immaterial,

(E) In *Disquisitions*, p. 37 and 102, it is asserted, that ideas are certainly divisible. "This seems to me very absurd. It would be as proper to assert ideas to be hard or round. The idea of an object is the apprehension, view, or notion of it; and how can this be divisible? Perception is a single and indivisible act. The object perceived may be divisible; but the *perception* of it by the mind cannot be so. It is said in page 95, *that if ideas are not things distinct from the mind, a mind with ideas and a mind without ideas would be the same.*—I maintain that ideas are not distinct from the mind, but its conceptions; or not *things* themselves, but *notions* of things. How does it follow from hence, that a mind with or without ideas is the same? It would seem that this follows much more from the contrary assertion." *Correspondence between Dr Price and Dr Priestley.*

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terial, can have no extension, is a truth which we think cannot be controverted; and if so, every thing in that principle must be *simple* and *indivisible*. Thus far we agree with Dr Priestley; but with respect to what follows we differ from him entirely. The agitation in the brain, which is the immediate cause of sensation, must indeed correspond to the impression *ab extra* by which it is produced, and therefore must have the property of extension; but that agitation, whatever it be, is not itself sensation, any more than a bludgeon is a blow, or a sword is a wound. Dr Priestley, indeed, in answer to Dr Price, affirms, that, according to Hartley's theory, ideas are only *vibrations in the brain*; but whoever shall take the trouble to examine that theory himself, will not find that its author ever advances such an opinion, or considers vibrations as any thing more than the instruments by which sensations and ideas are excited in the sentient principle. A real and proper idea, as we have often repeated, is nothing else than a fainter sensation: but no sensation, from whatever cause it may proceed, is itself extended; nor could we, without memory, the reasoning faculty, and the power of local motion, have acquired from mere sense any notion of extension at all: (see sect. 3. Chap. 1. Part I.). Sensations and ideas are those *appearances* (if we may so say), which vibrations or some other motion in the brain excite in the mind; but a *half* appearance is an absurdity. A man may view *half a tree* with his eyes, and he may contemplate the idea of *half a tree* in his mind; but he cannot have *half a view* or *half an idea* of any thing. Sensations and ideas result from the mutual agency of the brain and sentient principle upon each other; and if the agency of the brain be vibration, more of it may vibrate at one time than at another: but surely the mere relation between its agency at any time and the agency of the mind, can neither have extension nor be divisible; for who ever thought of extending or dividing relations? On this subject it is extremely difficult to write with perspicuity and precision; and what we have said may very possibly be misunderstood. Our notion is to ourselves clear and determinate; but language, which was not invented by metaphysicians, wants words in which it may be properly expressed. Perhaps the reader may understand what we mean, when we say that a sensation or an idea is the instantaneous effect of the mutual agency of the brain and sentient principle. Of this we think every man, by a little attention, may be perfectly convinced, though it may be impossible ever to discover the precise nature of this agency; and if so, it is plain that sensations and ideas cannot be divided, for no instantaneous effect of any kind is divisible. A sensation, and of course a simple and original idea, neither has extension itself, nor suggests the notion of extension *ab extra*. By running the hand or any other member along a solid body, we feel continued resistance: this feeling, or the idea of this feeling, becomes in time so closely associated with all our sensations of touch and sight, that the one cannot be separated from the other; and these associations are what Dr Priestley calls *extended ideas*. Upon the whole then, we think it apparent, that our sensations, and the relicks of our sensations, are unextended and indivisible (E); and that though they suggest

(F) We affirm this only of *human* sensations and ideas, because these are the only sensations and ideas of which we are conscious, and about which we can reason. Other animals are sentient as well as man, and appear to have their sensations excited by impressions *ab extra*; but whether in every species of animals a single impression excites but one sensation common to the whole animal, or different sensations which are felt each by a different faculty or sentient principle, is a question which we are not able to answer. We make this remark, because from the phenomena of sensation in the earthworm and other reptiles, some philosophers of eminence having supposed, that in these creatures the sentient faculty belongs to the material system, and is divisible with it; have thence concluded, we think rashly, that all arguments for the immateriality of the human mind are founded merely on our ignorance. We call this conclusion rash; because, though we know perfectly what a human sensation is, we have so little knowledge of the nature of sensation in worms, that what may be true of the one *principle* of sensation may be false of the other. Indeed, if we are to judge from the phenomena, this is actually the case. It appears from experiments made by Abbe Spallanzani and others, that if a certain number of rings be cut off either from the anterior or posterior part of a worm, or even from both, the remainder will not only continue to live and be sentient, but will also regenerate a new head and a new tail, and become again a complete worm. Nothing like this takes place in man or in the higher orders of animals; and therefore, were it certain that the sentient principle in the worm is diffused through the whole system, and divisible with it, we could not infer that the principle of such sensations as we are conscious of, is likewise extended and divisible. It is, however, so far from being certain that the sentient principle is diffused through the whole worm, that nothing necessarily follows from this fact, but that its seat is at some distance from either extremity. Nay, were it true, as perhaps it is, that a worm may be so divided, as that each of the two sections shall retain life, sensation, and this reproductive power, we would not therefore be authorized to conclude that the sentient principle is *one* coextended and divisible with the material system. The earthworm, like many other reptiles, being an hermaphrodite, which unites in itself both sexes, may possibly consist of two animated systems; which though united by some bond of connexion, by which sensation is communicated from the one to the other, are yet in themselves perfectly distinct. Should this, upon proper investigation, be found to be the case; and should it likewise be found, that when a worm is divided into three or more parts, only one or two of these parts continue to live, there would be no room whatever for supposing that even in these creatures the principle of sensation is extended and divisible. In the mere power of reproducing amputated parts, when that power is considered by itself, there is nothing more wonderful than in the growing of the nails of our fingers, or the hairs

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gest to us the existence of extended things *ab extra*, the sentient being *may* be unextended and indivisible.

Having thus examined Dr Priestley's auxiliary arguments for the materiality of mind, we now proceed to consider his main and direct proof. To this, as we have observed, so able a reply has been made, that it would be injustice to our readers not to lay it before them, in the words of its author. "I readily acknowledge (says this spirited essayist*) that the power of sensation or perception never having been found but in conjunction with a certain organized system of matter, we ought, as philosophers, to conclude that this power necessarily exists in, and results from, that organized system, unless it can be shown to be incompatible with other known properties of the same substance. On the other hand, it must be admitted, that constant conjunction implies *necessary* connexions only when reasons cannot be discovered to prove the conjunction to be accidental and arbitrary. In the present instance, it is alleged, that discerptibility is a property of matter absolutely incompatible with the property of sensation or perception; or in other words, that sensation is a power or property incapable of division. But as the power of the entire system is clearly nothing more than the sum or aggregate of the powers of all the parts, it necessarily follows, that the primary particles of which the system is composed must, upon the material hypothesis, possess distinct powers of sensation; and that those powers combined constitute the indivisible power of sensation belonging to the system; or, in other words, that the *indivisible* power of sensation is a *divisible* power, nay, an infinitely divisible power, if matter be, as philosophers in general allow, an infinitely divisible substance—a conclusion obviously and grossly ridiculous. We are then compelled to acknowledge, that sensation or perception is not the property of a material substance; i. e. if the common mode of expression be retained, it is the property of an immaterial substance; or, to avoid verbal contention, it is a property not resulting from, or necessarily connected with, the organical system, but a property wholly foreign, superinduced, and adventitious (G).

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Direct proof that the sentient principle in man cannot be a system of matter.

"In

* *Essays, Philosophical, Historical, and Literary*, vol. ii.

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hairs of our heads. The only thing which seems to militate against the simplicity of the principle of sensation in worms, is the continuance of life, &c. with both parts of a worm when cut into two by a knife or pair of scissars; but if a worm be found to have two seats of sensation analogous to the brain in higher animals, and if it be likewise found that life continues only in such sections as retain at least one seat of sensation, the sentient principle in the worm may be as simple and indivisible as in any animal whatever. We neither wish nor expect much stress to be laid upon these hints and conjectures. Should they induce any of our physiological readers, who have leisure, and are at the same time skilled in philosophy, properly so called, to institute a set of experiments upon worms and such reptiles, and to trace apparent effects to their higher causes, they might eventually lead to important discoveries. In the mean time, it is sufficient for our purpose to observe, that whatever be the sentient principle or principles in the earthworm, it is obvious that the whole animal cannot in any case be conscious, as man undoubtedly is, of *one individual sensation;* and that therefore no arguments built upon the phenomena accompanying sensation in worms, can be of any importance in the controversy about the materiality or immateriality of the human mind.

(G) This argument is not new. It was long ago urged by Dr Clarke against Mr Dodwell; and some of our readers may not be ill pleased to see it stated by so masterly a reasoner: "That the soul cannot possibly be *material*, is demonstrable from the single consideration of bare sense or consciousness. For matter being a divisible substance, consisting always of separable, nay of actually separate and distinct parts, it is plain that unless it were essentially conscious, in which case every particle of matter must consist of innumerable separate and distinct consciousnesses, no system of it, in any possible composition or division, can be an individual conscious being. For suppose three or three hundred particles of matter, at a mile or any given distance one from another, is it possible that all these separate parts should in that state be one individual conscious being? Suppose then all these particles brought together into one system, so as to touch one another, will they thereby, or by any motion or composition whatsoever, become one whit less truly distinct beings than they were when at the greatest distance? How then can their being disposed in any possible system make them one individual conscious being? If you will suppose God by his infinite power superadding consciousness to the united particles, yet still these particles being really and necessarily as distinct beings as ever, cannot be *themselves* the *subject* in which that individual consciousness inheres; but the consciousness can only be superadded by the addition of something, which in all the particles must still itself be but one individual being. The soul, therefore, whose power of thinking is undeniably one individual consciousness, cannot possibly be a material substance." *Clarke's Letter to Mr Dodwell*, 2d edition.

That the same mode of reasoning was known to the ancients, Cudworth has shown by numerous quotations; and as an argument certainly loses nothing by antiquity, or by having occurred to thinking men in distant ages, we shall lay before our readers two passages from Plotinus, of which the extract from Clarke's letter (though we are persuaded it was not borrowed by the author) must be considered as little more than a paraphrastical translation.——*τι τοινυν φησουσιν, οἱ την ψυχην σωμα ειναι λεγοντες, πρωτον μεν περι ἑκαστου μερους της ψυχης της εν τω αυτω σωματι, ποτερον ἑκαστον ψυχην, οἱα εστι και ἡ ὁλη; και παλιν του μερους το μερος; ουδεν αρα το μεγεθος συνεβαλλετο τη ουσια αυτης· καιτοι εδει γε ποσου τινος οντος· αλλα και ὁλον πολλαχη, οπερ σωμασι παρειναι αδυνατον, εν πλειοσι το αυτο ὁλον ειναι, και το μερος ὁ περ το ὁλον, ὑπαρχειν· εν δε ἑκαστον των μερων, ου ψυχην φησουσιν, εξ αψυχων ψυχη αυτοις υπαρξει.* *En.* IV. *Lib.* vii. *Cap.* 5.

The same argument is elsewhere stated thus: *ει δε ἑκαστον ζωην εχοι, και εν αρκει· ει δε μηδενος αυτων ζωην εχοντος ἡ συνοδος πεποιηκε ζωην, ατοπον· μαλλον δε αδυνατον συμφορησιν σωματων ζωην εργαζεσθαι, και νουν γενναν τα ανοητα.* *En.* IV. *Lib.* ii. *Cap.* 2.

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"In opposition to this reasoning, the materialists affirm, that entire systems may possess, and they think themselves warranted to pronounce that organized systems of matter actually do possess, powers essentially different from those which inhere in the several parts. Amongst various familiar though striking illustrations of this truth, it has been said, that a rose possesses the property of sweetness or fragrance, a globe the property of sphericity, a harpsichord the property or power of producing harmony, *aqua regia* the property of dissolving gold, &c. though the component particles of these different organized systems are themselves totally destitute of the powers and properties here enumerated.

"The immaterialists, in reply, assert, that it is not only false in fact, but a direct contradiction, and an absolute impossibility in the nature of things, that a system should possess any property which does not inhere in its component parts. To assert that the power of the whole is the sum or aggregate of the powers of all the parts, is an identical and self-evident proposition, the whole and all the parts being terms precisely synonymous. Whoever, therefore, calls in question the truth of this axiom, must maintain that the power of the whole is something different from the power of all the parts, i. e. that the power of the whole is *not* the power of the whole.

"It will be easy to demonstrate the correspondence of facts with this plain and simple theory. For this purpose, it is necessary to observe, that the properties of matter, or what are generally denominated such, may be divided into real and nominal, which Locke and others have called primary and secondary qualities. Figure, magnitude, and motion, are qualities really inherent in matter; but figure, magnitude, and motion, eternally varied, can produce only different combinations of figure, magnitude, and motion. There are also powers, or qualities, vulgarly considered as inherent properties of matter organically disposed, which are really and truly qualities or affections of the mental or percipient principle, and have no existence when not perceived. Thus the sweetness or fragrance of the rose, considered as mere sweetness and fragrance, can be nothing but an affection of the mind; considered as a quality of the rose, they can mean nothing more than a certain arrangement, configuration, and motion of parts, which in some inexplicable manner produces the sensation of sweetness. In this instance, therefore, the power of the whole is plainly the aggregate of the powers residing in the parts, by the motion and organization of which a certain effect is produced upon a foreign and percipient substance.

"But a globe, we are told, possesses the property of sphericity, though not a single particle amongst that infinite number of which the globe is constituted is itself of a spherical form. The fallacy of this illustration is, however, as easily demonstrable as that of the former. The sphericity of a globe is evidently the sum or aggregate of the curvilinear or convex parts which compose its surface; and the property of the whole is neither more nor less than the combined properties of all its parts. No one doubts, that by new compositions or arrangement of material particles possessing magnitude, figure, and motion, an endless diversity of phenomena may be produced, to which it may be necessary to apply new names. New names, however, do not constitute new properties; and though we give to a globe the appellation of an entire system, and ascribe to it the property of sphericity, we know at the same time that it is really nothing more than a collection of thousands of millions of particles, actually separate and distinct, arranged in that particular form which we denominate spherical. But this can never be regarded as in the remotest manner analogous to the *creation* of the power of perception, in consequence of a certain organical arrangement or disposition of impercipient particles. Though sphericity is, indeed, the property of the entire sphere, yet every part of the sphere, if divided, possesses its share of sphericity. But if the percipient principle be divided, what would become of the power of perception? A sphere equally divided becomes two hemispheres; Does a perception, when divided in like manner, become two demi-perceptions?

"The same reasonings may easily be transferred, and applied to the harpsichord. Can any one be absurd enough to affirm that the power of harmony resides in the harpsichord, as the power of perception does in the mind? After the utmost skill of the artificer has been exerted, we discover nothing more in the harpsichord than new modifications of the old properties of figure, magnitude, and motion, by means of which certain vibrations are communicated to the air, which, conveyed by the medium of the auditory nerves to the sensorium, produce the sensation of harmonic sounds. These new modifications are therefore attended, indeed, with new and very wonderful effects; but then those effects are produced upon, and are themselves modifications of, the sentient or percipient faculty. And though it is wholly incomprehensible to us in what manner these effects, that is, these *sensations*, are produced, we well know, and perfectly comprehend, that they are not new powers belonging to any organized system of matter; that they have no existence but in a mind perceiving them; and that they are far from militating against that grand and universal axiom, that the power of the whole is nothing more than the united powers of all the parts.

"As to the last instance adduced, of the power of *aqua regia* to dissolve gold, though neither the spirit of salt, nor the spirit of nitre of which it is compounded, separately possesses that power, it is plain, that from the union of these two substances, certain new modes of configuration and motion result; and the solution of gold is the consequence of this new arrangement and motion of the parts. But the particles of which the menstruum is composed were always possessed of the properties of figure and motion; and what is styled a new property, is clearly nothing more than a new effect of the old properties differently modified. In a word, the advocates for materialism may safely be challenged to produce, in the whole compass of nature, a case which bears the least analogy to that which these instances are most unphilosophically adduced to prove and to illustrate. It is an absurdity which transubstantiation itself does not exceed, to maintain that a whole is in reality any thing different from its component parts: and all nature rises up in confutation of an assertion so monstrous and extravagant. To affirm that perception can arise from any combination of impercipient particles, is as truly ridiculous, as to affirm that

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that a combination of the seven primary colours with the four cardinal virtues may constitute a planet. It is equivalent to an assertion, that an epic poem might be composed of parallelograms, cones, and triangles. In a word, it is an absurdity not less real, and a little less obvious, than that of the blind man who thought that the idea of a scarlet colour resembled the sound of a trumpet."

If matter be taken in the common acceptation, to be a solid, extended, and inert substance, this reasoning for the immateriality of the sentient principle in man appears to us to have the force of demonstration, which no difficulties or partial objections, arising from our inability to conceive the band of union between two such heterogeneous substances as mind and body, can ever weaken, and far less overturn. But the modern materialists deny that matter is either solid or inert. "All those facts (say they) which led philosophers to suppose that matter is impenetrable to other matter, later and more accurate observations have shown to be owing to *something else* than solidity and impenetrability, viz. a *power of repulsion*, which for that reason they would substitute in its place. The property of *attraction* or repulsion (says Dr Priestley) appears to me not to be properly what is *imparted* to matter, but what really *makes it to be what it is;* insomuch, that without it, it would be nothing at all; and as other philosophers have said,—'Take away solidity, and matter vanishes,' so I say, 'Take away attraction and repulsion, and matter vanishes." If this be admitted, the ingenious author hopes that we shall not consider matter with that contempt and disgust with which it has generally been treated, there being nothing in its real nature that can justify such sentiments respecting it.

235 Reply by the materialists shown

236 to be absurd.

We know not why, upon any hypothesis, matter should be viewed with contempt and disgust.—Whether penetrable or impenetrable, every consistent theist considers it as one of the creatures of God, perfectly fitted to answer all the purposes for which it was intended: but were it really destitute of solidity, and endowed with the powers of attraction and repulsion, we should still be obliged to consider it as incapable of the powers of sensation and thought. If we have any notion at all of what is meant by centres of attraction and repulsion (of which indeed we are far from being confident), it appears to us to be intuitively certain, that nothing can be the result of any possible combination of such centres, but new and more enlarged spheres of attraction and repulsion. But surely consciousness, sensation, and will, are as different from attraction and repulsion, as a cube is from the sound of a trumpet, or as the sensations of a felon in the agonies of death are from the attraction of the rope by which he is hanged. If this be admitted, and we are persuaded it will be denied by no man whose understanding is not clouded by an undue attachment to paradoxes, the sentient principle cannot possibly be matter; for if, when the powers of attraction and repulsion are taken away, matter vanishes; and if consciousness and sensation are not attraction and repulsion; it is not more evident that three and two are not nine, than that the substance which attracts and repels cannot be that which is conscious and percipient.

237 Locke's opinion hasty and ill-founded,

Locke, who was certainly no materialist, as he repeatedly affirmed, and indeed demonstrated, that thought could never be the result of any combinations of figure, magnitude, and motion, was yet of opinion, that God by his almighty power might endow some systems of matter with the faculties of thinking and willing. It is always with reluctance that we controvert the opinions of so great a man; and it is with some degree of horror that we venture in any case to call in question the power of Omnipotence.—But Omnipotence itself cannot work contradictions; and it appears to us nothing short of a contradiction, to suppose the individual power of perception inhering in a system which is itself extended and made up of a number of separate and distinct substances. For let us suppose such a system to be six feet long, three feet broad, and two feet deep (and we may as well suppose a system of these dimensions to be percipient, as one that is smaller) then it is plain, that every idea must be extended, and that part of it must be in one place, and part in another. If so, the idea of a square inch will be six feet long, three feet broad, and two feet deep; and what is still harder to be digested, the several parts of this idea will be at a great distance from each other, without any bond of union among them. The being which apprehends one extremity of the idea, is, by the supposition, six feet distant from the being which apprehends the other extremity; and though these two distinct beings belong to one system, they are not only separable, but actually separated from each other as all the particles of matter are. What is it then that apprehends as *one* the whole of this extended idea? Part of it may be apprehended by one particle of matter, and part of it by another; and there is nothing which apprehends or can apprehend, the whole. Perhaps it will be said, the power of apprehension is not divided into parts, but is the power of the one system, and therefore apprehends at once the whole idea. But a power or faculty cannot be separated from its subject, power which inheres in nothing being confessedly impossible; and a material system is not *one subject* in which any individual power or faculty can inhere. There must, therefore, be united to the system some *one* being, which is the subject of thought, and which is unextended as well as indivisible. This, we say, follows undeniably. For, let us suppose, that an extended being without separate parts is possible, and that such a being is percipient; it is obvious, that the whole of any one of its perceptions could not be in one place. Now, though we should grant to Dr Priestley and other materialists, that every idea of an extended substance has itself three dimensions, and is incorporated and commensurate with the whole percipient system; what, upon this supposition, shall we think of consciousness and of the perception of truth? Is consciousness or truth extended? If so, one side or superficies of consciousness, or of a truth, may be greater or less than another, above or below, to the right or to the left; and it will be very proper and philosophical to speak of the length, breadth, and depth, of consciousness or of truth. But surely to talk of the place or the extension of these things, is as absurd as to talk of the colour of sound, or the sound of a triangle; and we might as well say, that consciousness is green or red, as that it is an ell or an inch long;

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long; and that truth is blue, as that it has three dimensions.

This reasoning is somewhat differently stated by Cudworth; who observes, that if the soul be an extended substance, "it must of necessity be either a physical point (i. e. the least extension possible, if there be any such least extension), or else it must consist of more such physical points joined together. As for the former of these, it is impossible that *one single atom*, or *smallest point* of extension, should be able to perceive distinctly all the *variety* of things, i. e. take notice of all the *distinct* and *different* parts of an *extended object*, and have a *description* or *delineation* of the whole of them upon itself (for that would be to make it the least, and not the least, possible extension at the same time: Besides, to suppose every soul to be but one *physical point*, or the smallest *possible extension*, is to suppose such an essential difference in matter or extension, as that some of the *points* thereof should be *naturally* devoid of all *life*, *sense*, and *understanding;* and others again, naturally *sensitive* and *rational*. And even should this absurdity be admitted, it would yet be utterly inconceivable how there should be *one*, and *but* one, *sensitive* and *rational* atom in every man; how this atom of so *small* dimension, should actuate the whole system; and how it should constantly remain the same from infancy to old age, whilst all the other parts of the system transpire perpetually, and are succeeded by new matter (H).

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"But if, according to the second hypothesis, souls be extended substances consisting of many points one without another, and all concurring in every sensation; then must every one of these points perceive either a *point* only of the object, or else the *whole*. Now, if every *point* of the *extended soul* perceives only a *point* of the *object*, then there is no *one thing* in us that perceives the whole, or that can compare one part of the object with another. On the other hand, if every *point* of the *extended soul* perceive the *whole object* at once, then would there be *innumerable perceptions* of the same object in every sensation; as many, indeed, as there are points in the extended soul.—And from both these suppositions it would alike follow, that no man is *one single percipient* or person, but that in every man there are innumerable distinct *percipients* or *persons*; a conclusion directly contrary to the infallible evidence of consciousness (I)."

Cogent as these arguments for the immateriality of

(H) Should it be said, that this essential difference between the atoms of matter is not fortuitous; that some of them are created intelligent for the express purpose of animating systems of others which are unintelligent: and that these intelligent atoms do not operate upon the systems with which they are united, by the *vis inertiæ*, *solidity*, or *extension*, of matter, but by the energies of understanding and will: Should this (we say) be alleged, surely it may be asked, for what purpose they are conceived to have the quality of extension? It is evidently of no use; and it has been already shown, and shall be more fully shown afterwards, that by our notions of consciousness and understanding, we are so far from being led to suppose the subject of these powers extended, that we cannot suppose any relation whatever between them and extension. But if these intelligent atoms be divested of their quality of extension, they will be transformed from matter to mind, and become the very things for the existence of which we plead.

(I) As the materialists endeavour to prejudice the public against the notion of an unextended soul, by representing it as a fiction of *Des Cartes*, altogether unknown to the ancients, it may not be improper to give our readers an opportunity of judging for themselves how far this representation is just.—*Plotinus*, reasoning about the nature of the soul from its energies of sensation, expresses himself in these words:—ειτι μελλει αισθανεσθαι τινος, ἑν αυτο δει ειναι, και τω αυτω παντος αντιλαμβανεσθαι και ει δια πολλων αισθητηριων πλειω τα εισιοντα, ἡ πολλαι περι ἑν ποιοτητης και δι ἑνος ποικιλον, ὁιον προσωπον· ου γαρ αλλο μεν ρινος αλλο δε οφθαλμων, αλλα ταυτον ὁμου παντωνι και ει το μεν δι ομματων το δε δι ακοης, εν τι δει ειναι εις ὁ αμφω· ἡ πως αν ειποι ὁτι ἑτερα ταυτα, μη εις το αυτο ὁμου των αισθησεων ελθοντων. "That which perceives in us, must of necessity be one thing, and by one and the same indivisible perceive all; and that whether they be more things entering through several organs of sense, as the many qualities of one substance, or one various and multiform thing, entering through the same organ, as the countenance and picture of a man. For it is not one thing in us that perceives the nose, and another thing the eyes; but it is one and the self-same thing that perceiveth all. And when one thing enters through the eyes, another through the ears, both these also must of necessity come at last to one indivisible; otherwise they could not be compared together, nor one of them be affirmed to be different from the other, the several ideas of them meeting nowhere in one place." Pursuing the same argument, and having observed, that if what perceiveth in us be extended, then one of these three things must of necessity be affirmed, that either every part of this extended soul perceives a part only of the object, or every part of it the whole object; or else, that all comes to some one point, which alone perceives both the several parts of the object and the whole: he observes of the first of these suppositions,—μεγεθει οντι τουτω, ζυμμεριζοιτο αν· ωστε αλλο αλλου μερος, και μηδενα ἡμων ὁλου του αισθητου αντιληψιν εχειν· ὡσπερ αν ει εγω μεν αλλου· συ δε αλλου αισθοιο: "If the soul be a magnitude, then must it be divided, together with the sensible object, so that one part of the soul must perceive one part of the object, and another another; and nothing in it, the whole sensible; just as I should have the sense of one thing, and you of another." Of the second supposition he writes in this manner: ει δε ὁτιουν παντος αισθησεται· εις απειρα διαιρεισθαι του μεγεθους πεφυκοτος απειρους και αισθησεις καθ' εκαστον αισθητον συμβησεται γιγνεσθαι ἑκαστω ὁιον του αυτου απειρους εν τω ἑγεμονουντι ἡμων εικονας: "But if every part of the extended soul perceive the whole sensible object, since magnitude is infinitely divisible, there must be in every man infinite sensations and images of one object."—And as for the third and last part of this disjunction, Plotinus by asserting the infinite divisibility of body, here shows that the supposition of any one physical point is in itself an absurdity. But if it were not, he agrees with Aristotle

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of the sentient principle appear to be, they have been lately treated with the most sovereign contempt by a writer who professes to be a disciple of Dr Priestley's, but who seems not to have learned the modesty or the candour of his master. Dr Priestley labours to prove, that to account for the phenomena of perception and volition, &c. it is not necessary to suppose an immaterial principle in man. Mr Cooper with greater boldness affirms, and undertakes to demonstrate with all the parade of mathematical precision*, that such a principle is impossible. Though the authority of this philosopher in such inquiries as depend not immediately upon the retort and the furnace, is certainly not great, he yet utters his dogmas with such confidence, that it may not be improper to examine the chief arguments upon which they rest.

* Tracts Ethical, Theological, and Political, vol. i.

239 An attempt to prove the impossibility of immaterial substance.

"Suppose (says he) the soul to have no common property with matter; then, no thing can act upon any other but by means of some common property. Of this we have not only all the proof that induction of known and acknowledged cases can furnish, but that additional proof also which arises from the impossibility of conceiving how the opposite proposition *can* be true. But by the supposition, the soul has no property in common with matter; and therefore the soul cannot act upon matter. But by the supposition of every system of immaterialism (except those of Malebranche, Berkeley, and Leibnitz), it is deemed an essential property of the soul, that it acts upon the body, or upon matter; therefore the soul can and cannot act upon matter at the same time, and in the same respect. But this is a contradiction in terms; and as two contradictions cannot both be true at the same time, the supposition of the existence of an immaterial soul cannot be true; that is, the soul does not exist."

240 shown to be futile.

This reasoning, the reader will observe, is carried on with all the pomp of mode and figure. The propositions hang upon each other like the several steps of an algebraic process: but as in such processes one error unwarily admitted produces a false result, so in demonstrative reasonings one unsound argument admitted into the premises is necessarily productive of error in the conclusion. When the author affirms, "that no thing can act upon any other but by means of some common property," he affirms without the shadow of proof what is certainly not self-evident. He says, indeed, that of this we have all the proof that induction of known and acknowledged cases can furnish; but unless consciousness be calculated to deceive us, this is unquestionably a mistake. Matter, he repeatedly affirms, has no other properties than those of attraction and repulsion: but a man moves his arm by a mere energy of will; and therefore, according to this demonstrator, an energy of will must be either material attraction or material repulsion. If so, it is reasonable to conclude, that when a man draws his hand towards his head, the centre of his brain exerts its power of *attraction*; and that when he extends his arm at full length before him, the same centre exerts its power of *repulsion*. We beg pardon of our readers for detaining them one moment upon such absurdities as these: yet we cannot dismiss the argument without taking the liberty to ask our all-knowing author, How it comes to pass that the same centre sometimes attracts and sometimes repels the same substance at the same distance; nay, that it both attracts and repels substances of the same kind, at equal distances, and at the very same instant of time? This must be the case, when a man puts one hand to his head, and thrusts another from him; and therefore, if these operations be the effect of attraction and repulsion, it must be of attraction and repulsion to which induction of known and acknowledged cases furnishes nothing similar or analogous, i. e. of such attraction and repulsion as, according to Mr Cooper's mode of reasoning, does not exist. The truth is, that we are not more certain that we ourselves exist, than that an energy of will is neither attraction nor repulsion; and therefore, unless all matter be endued with will, it is undeniable, that, whatever be the substance of the soul, one thing acts upon another by a property not common to them both. In what *manner* it thus acts, we pretend not to know: but our ignorance of the *manner* of any operation is no argument against the *reality* of the *operation itself*, when we have for it the evidence of consciousness and daily experience; and when the author shall have explained to general satisfaction how material centres attract and repel each other at a distance, we shall undertake to explain how one thing acts upon another with which it has no common properties.

241 A second attempt of the same kind.

Suspicious, as it should seem, that this reasoning has not the complete force of mathematical demonstration, the author supports his opinion by other arguments. "Whatever we know (says he), we know by means of its properties, nor do we in any case whatever certainly know any thing but these; and we infer in all cases the existence of any thing which we suppose to exist from the existence of its properties. In short, our idea of any thing is made up of a combination of our ideas of its properties. Gold is heavy, ductile, tenacious, opaque, yellow, soluble in *aqua regia*, &c. Now, let any one suppose for an instant that gold is deprived of all these, and becomes neither heavy, ductile, tenacious, opaque, yellow, soluble, &c. what remains, will it be gold? Certainly not. If it have other properties, it is another substance. It it have no properties remaining, it is nothing. For nothing is that which hath no properties. Therefore, if any thing lose all its properties, it becomes nothing; that is, it loses its existence. Now, the existence of the soul is inferred, like, the existence of every thing else, from its supposed properties, which are the phenomena of thinking, such as perception, recollection, judgment, and volition. But in all cases of *perfect* sleep, of the operation of a strong narcotic, of apoplexy, of swooning, of drowning where the vital powers are not extinguished, of the effects of a violent blow on the back

Aristotle in asking πως τω αμιξει το μεγιστον.—thereby plainly indicating, that the sentient principle is totally separated from extension, and can neither be considered as extended like a superficies or solid, nor unextended as a physical point.

back part of the head, and all other leipothymic affections, there is neither perception, recollection, judgement, nor volition; that is, all the properties of the soul are gone, are extinguished. Therefore, the soul itself loses its existence for the time. If any man shall say, that these properties are only *suspended* for the time, I would desire him to examine what idea he annexes to this suspension; whether it be not neither more nor less than that *they are made not to exist for the time.* Either no more is meant, or it is contradictory to matter of fact; and moreover, if more *be* meant, it may easily be perceived to involve the archetypal existence of abstract ideas, and to contradict the axiom *impossibile est idem esse et non esse.*"

42 sh n to be ually w.

For the benefit of short-sighted inquirers, it is to be wished that the author had favoured the public with this *proof* which might have been so easily brought; for we can discern no connexion whatever between the suspension of the exercise of the powers of the mind, and the archetypal existence of abstract ideas, or the absurd proposition that it is *possible for the same thing to be and not to be.* We think, however, that we understand enough of this reasoning which he has given us to be able to pronounce with some confidence that it is nothing to the purpose. For, in the *first* place, We beg leave to observe, that between the properties of gold and the powers of thinking, &c. there is no similarity; and that what may be true when affirmed of the one, may be false when affirmed of the other. The powers of the mind are all more or less active; the enumerated properties of gold are all passive. We know by the most complete of all evidence, that the exercise of power *may be* suspended, and the power itself remain unimpaired; but to talk of the suspension of the energies of what was never energetic, if it be not to contradict the axiom *impossibile est idem esse et non esse*, is certainly to employ words which have no meaning. Yet even this argument from the properties of gold might have led the author to suspect that something else may be meant by the suspension of the exercise of powers, than that *those powers are made not to exist for the time.* In a room perfectly dark gold is not yellow; but does it lose any of its essential properties, and become a different substance, merely by being carried from light to darkness? Is a man while in a dark room deprived of the faculty of sight, and one of the powers of his mind made not to exist for the time? The author will not affirm that either of these events takes place. He will tell us that gold exhibits not its yellow appearance, merely because the proper medium of light passes not from it to the eye of the percipient, and that it is only for want of the same medium that nothing is seen by us in perfect darkness. Here, then, by his own confession, is a power of the mind, and a property of an external object, both suspended in their energies, without being annihilated; and no proof has yet been brought that all the powers of the mind may not in the same manner be suspended in their energies without being made not to exist. As light is necessary to vision, but is not itself either the thing which sees or the thing which is seen; so may the brain be necessary to the phenomena of thinking, without being either that which thinks, or that which is thought upon: and as actual vision ceases when light is withdrawn, though the eye and the object both continue to exist; so may the *energy* of thinking cease when the brain is rendered unfit for its usual office, though the being which thinks, and the power of thought, continue to exist, and to exist unimpaired. That this is actually the case every man must be convinced who believes that in thinking he exerts the same powers to-day that he exerted yesterday; and therefore our author's second demonstration of the nonexistence of mind is, like his first, founded upon assertions which cannot be granted.

243 A third attempt of the same kind

Another of these pretended demonstrations is as follows: "If the soul exist at all, it must exist somewhere; for it is impossible to frame to one's self an idea of any thing existing, which exists nowhere. But if the soul exist somewhere, by the terms it occupies space, and therefore is extended; but whatever has extension, has figure in consequence thereof. The soul then, if it exist, hath the properties of extension and figure in common with matter. Moreover, by the supposition of every immaterial hypothesis (except those of Malebranche, Berkeley, and Leibnitz), it acts upon body, i. e. upon matter; that is, it attracts and repels, and is attracted and repelled, for there is no conceivable affection of matter but what is founded on its properties of attraction and repulsion; and if it be attracted and repelled, its reaction must be attraction and repulsion. The soul then has the properties of extension, figure, attraction and repulsion, or solidity. But these comprise every property which matter, as such, has ever been supposed to possess. Therefore the soul is matter, or material. But by the supposition it is immaterial; therefore it does not exist. For nothing can exist whose existence implies a contradiction."

244 shown to confute itself.

Mr Cooper, we see, still proceeds in the direct road of mathematical demonstration; but in the present instance we beg leave to stop him in the very beginning of his course, and to ask *where* the universe exists? When he shall have given such an answer to this question as men of common sense may be able to comprehend, we may perhaps attempt to tell him where an unextended soul exists. If this demonstration be not a collection of words without meaning, the existence of space as a real thing is taken for granted. Space, therefore, has extension, and of course figure; but we believe Mr Cooper will find some difficulty in ascertaining the figure of infinite space. The mind certainly acts upon body. For this we have the evidence of consciousness and experience; but we have no evidence whatever that it must therefore attract and repel, and be attracted and repelled. It has been already observed, that the mind, whatever be its substance, acts upon the body by energies of will. What these are every man knows with the utmost certainty and precision; whilst we may venture to assert, that no man knows precisely what corpuscular attraction and repulsion are, supposing the existence of such powers to be possible. When we speak of attraction and repulsion, we have some obscure notion of bodies acting upon each other at a distance; and this is all that we know of the matter. But when we think of an energy of the human will, the idea of distance neither enters nor can enter into our notion of such an energy. These are facts which we pretend not to prove by a mathematical or a chemical process. Every man must be convinced

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convinced of their truth by evidence more complete than any proof, viz. immediate consciousness of his own thoughts and volitions. This being the case, we may turn Mr Cooper's artillery against himself, and because mind acts upon body by powers different from attraction and repulsion, argue that body neither attracts nor repels; and were it true, as it is certainly false, that no thing could act upon another but by means of some property common to both, we might infer that every atom of matter is endowed with the powers of volition and intelligence, and by consequence that every man is not one but ten thousand conscious beings, a conclusion which our philosopher seems not inclined to admit.

245 Objections to the doctrine of immaterialism stated and answered.

Having finished his *demonstrations*, the author states other objections to the doctrine of immaterialism which, as they are not his own nor new, have greater weight. "It appears no more than reasonable (says he), that if the doctrine of materialism be rejected as inadequate to explain the phenomena, these latter should at least be explained in some manner or other better upon the *substituted* than the *rejected* hypothesis; so that it is reasonable to require of an immaterialist that his supposition of a distinct soul should explain the *rationale* of the phenomena of thinking. But, strange to say, so far from attempting to explain these phenomena on the immaterial hypothesis, it is acknowledged on all hands that even on this hypothesis the phenomena are inexplicable." This objection it would certainly be no difficult task to obviate; but from that trouble, small as it is, we are happily exempted by the objector. "I would have it understood (says he), that no materialist ever undertook to say *how* perception results from our organization. What a materialist undertakes to assert is, that perception, *whatever* it be, or *however* it results from, does actually result from our organization." According to Mr Cooper, then, the *rationale* of thinking is equally inexplicable by materialists and immaterialists; and the truth is, that we know the *rationale* of hardly any one operation in nature. We see that the stroke of a racket produces motion in a billiard ball; but how it does so, we believe no man can say. Of the fact, however, we are certain; and know that the motion is produced by some power, about the effects of which we can reason with precision. In like manner we know with the utmost certainty, that we ourselves have the powers of perception and volition; and that these powers cannot be conceived as either an ell or an inch long. How they result from the mutual agency of an immaterial and material substance upon each other, we are indeed profoundly ignorant; but that such is the fact, and that they are not the result of mere organization, we must necessarily believe, so long as it is true that the power of the entire system is nothing more than the sum or aggregate of the powers of all its parts. The immaterial hypothesis contains in it something inexplicable by man: The material hypothesis likewise contains, by the confession of its advocates something that is equally inexplicable; and is over and above burdened with this contradiction, that the whole is something different from all its parts. It is therefore *no* "singular phenomenon in literary history, that one hypothesis should be rejected as inadequate to account for appearances, and that the hypothesis substituted should, even by the acknowledgment of its abettors, be such as not only not to explain the *rationale* of the appearances, but from the nature of it, to preclude all hopes of such an explanation." This is exactly the case with respect to a *vacuum* in astronomy. That hypothesis does not in the least tend to explain the rationale of the motions of the planets; but yet it must be admitted in preference to a *plenum*, because upon this last hypothesis motion is impossible.

246 Whether as many things may be asserted of the soul as of the body.

"Supposing the existence of the soul, it is an unfortunate circumstance (says Mr Cooper), that we cannot properly assert positively any thing of it at all." Were this the case, it would indeed be a very unfortunate circumstance; but can we not assert positively as many things of the soul as we can of the body? Can we not say with as much propriety and certainty, that the soul has the powers of perception and volition, &c. as that the body is solid and extended, or as that matter has the powers of attraction and repulsion? We know perfectly what perception and volition are, though we cannot have *ideas* or mental images of them; and if our author knows what attraction and repulsion are, we believe he will not pretend to have of them ideas entirely abstracted from their objects. "But granting the soul's existence, it may be asked (says he), Of what use is an hypothesis of which no more can be asserted than its existence?" We have just observed that much more can be asserted of the soul than its existence, viz. that it is something of which perception and will are properties; and he himself asserts nothing of matter but that it is something of which attraction and repulsion are properties.

"This soul, of which these gentlemen (the immaterialists) are conscious, is immaterial essentially. Now I deny (says our author), that we can have any idea at all of a substance purely immaterial." He elsewhere says, that nothing can exist which is not extended, or that extension is inseparable from our notions of existence. Taking the word *idea* in its proper sense, to denote that appearance which external objects make in the imagination, it is certainly true that we can have no *idea* of an immaterial substance; but neither have we, in that sense, any idea of matter abstracted from its qualities. Has Mr Cooper any *idea* of that which attracts and repels, or of attraction and repulsion, abstracted from their objects? He may perhaps, have, though we have not, very adequate ideas of bodies acting upon each other at a distance; but as he takes the liberty to substitute assertions for arguments, we beg leave in our turn to assert, that those ideas neither are, nor can be, more clear and adequate than our notion of perception, consciousness, and will, united in one being.

247 Extension not inseparable from all notion of existence.

That extension is no otherwise inseparable from our notions of existence than by the power of an early and perpetual association, is evident from this circumstance, that, had we never possessed the senses of sight and touch, we never could have acquired any idea at all of extension. No man, who has thought on the subject, will venture to affirm, that it is absolutely impossible for an intelligent being to exist with no other senses than those of smell, taste, and hearing. Now it is obvious that such a being must acquire some notion of existence

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istence from his own consciousness: but into that notion extension could not possibly enter; for neither sounds, tastes, smells, nor consciousness, are extended; and it is a fundamental article of the materialists creed, that all our ideas are relicks of sensation. Since then existence may be conceived without extension, it may be inferred that they are not inseparable from each other; and since cogitation cannot be conceived with extension, we may reasonably conclude, that the being which thinks is not extended.

Mr Cooper indeed, with his master, talks of extended ideas and extended thoughts: but we must assert, in the words of Cudworth, that "we cannot conceive a *thought* to be of such a certain *length*, *breadth*, and *thickness*, measurable by *inches*, *feet*, and *yards;* that we cannot conceive the *half*, or *third*, or *twentieth* part of a thought; and that we cannot conceive every thought to be of some determinate *figure*, such as *round* or *angular*, *spherical*, *cubical*, *cylindrical*, or the like. Whereas if extension were inseparable from existence, *thoughts* must either be mere *nonentities*, or extended into *length*, *breadth*, and *thickness;* and consequently all truths in us (being nothing but complex thoughts) must be long, broad, and thick, and of some determinate figure. The same must likewise be affirmed of volitions, appetites, and passions, and of all other things belonging to cogitative beings; such as knowledge and ignorance, wisdom and folly, virtue and vice, &c. that these are either all of them absolute *nonentities*, or else extended into three dimensions, and measurable not only by *inches* and *feet*, but also by solid measures, such as *pints* and *quarts*. But if this be absurd, and if these things belonging to soul and mind (though doubtless as great realities at least as the things which belong to body) be *unextended*, then must the substances of souls or minds be themselves unextended, according to that of Plotinus, νους ου διαστας αφ ἑαυτου, and therefore the human soul cannot be material."

248 That the human soul cannot exert its faculties but in union with some corporeal system, an opinion probable and

Mr Cooper employs many other arguments to prove the materiality of the sentient principle in man; but the force of them extends no farther than to make it in the highest degree probable, that the mind cannot exert its faculties but in union with some organized corporeal system. This is an opinion which we feel not ourselves inclined to controvert; and therefore we shall not make any particular remarks upon that part of our author's reasonings. That an immaterial and indiscerptible being, such as the soul, is not liable to be *dissolved* with the body, is a fact which cannot be controverted: for what has no parts can perish only by *annihilation;* and of annihilation the annals of the world afford no instance. That an immaterial being, endowed with the powers of perception and volition, &c. *may be capable* of exerting these powers in a state of separation from all body, and that at least one immaterial Being does actually so exert them, or other powers analogous to them, are truths which no man whose arrogance does not surpass his judgment will venture to deny; but the question at present between the most rigid immaterialists and their opponents, is, whether there be ground to think that the human soul is such a being?

Now, when Mr Baxter and his followers confidently affirm, that human perception must *necessarily* subsist after the dissolution of the present mortal and perishable system; and that the soul, when disencumbered of *all body*, will have its faculties greatly *enlarged;* they affirm what to us appears incapable of proof. That a disembodied soul *may* perceive, and think, and act, and that its powers of intellection *may* have a wider range than when they were circumscribed by a corporeal system, which permitted their action upon external objects only through five organs of sense, is certainly *possible;* and the argument by which the materialists pretend to prove it *not* possible, is one of the most contemptible sophisms that ever disgraced the page of philosophy. To affirm, that because our intellectual powers, in their embodied state, seem to decay with the system to which they are united, the mind, when set free, must therefore have no such powers at all, is equally absurd as to say, that because a man shut up in a room which has but one window sees objects less and less distinctly as the glass becomes more and more dimmed, he must in the open air be deprived of the power of vision. But because the human soul *may*, for any thing that we see to the contrary, subsist, and think, and act, in a separate state, it does not therefore necessarily follow that it *will* do so; and every thing that we know of its nature and its energies leads us to think, that without some kind of body by which to act as by an instrument, all its powers would continue dormant. There is not the shadow of a reason to suppose that it existed and was conscious in a prior state; and as its memory at present, unquestionably depends upon the state of the brain, there is all the evidence of which the case will admit, that if it should subsist in a future state divested of all body, though it might be endowed with new and enlarged powers of *perception*, it could have no *recollection* of what it did and suffered in *this world*, and therefore would not be a fit object either of reward or of punishment. This consideration has compelled many thinking men, both Pagans and Christians, to suppose that at death the soul carries with it a fine material vehicle, which is its immediate sensorium in this world, and continues to be the seat of its recollection in the next. Such, as we have seen, was the opinion of Mr Wollaston and Dr Hartley; it was likewise the opinion of Cudworth and Locke, who held that the Supreme Being alone is the only mind wholly separated from matter; and it is an opinion which even Dr Clarke, one of the ablest advocates for immaterialism, would not venture positively to deny.

249 ancient.

Nor is this opinion peculiar to a few moderns. Cudworth, after giving a vast number of quotations from Pythagoreans and Platonists, which prove to a demonstration that they held the Deity to be the only mind which perceives and acts without the instrumentality of matter, observes, "from what hath been said, it appeareth, that the most ancient assertors of the incorporeity and immortality of the human soul, yet supposed it to be always conjoined with some body." Thus *Hierocles* plainly: ἡ λογικη ουσια συμφυες εχουσα σωμα. ὁυλω παρα του δημιουργου εις το ειναι παρηλθεν, ως μητε το σωμα ειναι αυλην, μητε ανευ σωματος· αλλ αυλην μεν ασωματον, αποπερα τουσθαι δε εις σωμα το ὁλον αυλης ειδος. *The rational nature having always a kindred body, so proceeded from the demiurgus, as that neither itself is body, nor yet can it be without body; but though itself be incorporeal, yet its whole form is terminated in a body.*

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body. Agreeably to this the definition which he gives of a man is, ψυχη λογικη μετα συμφυους αθανατου σωματος, *a rational soul, together with a kindred immortal body;* and he affirms, that our present animated terrestrial body, or mortal man, is nothing but ἔιδωλον ανθρωπου, *the image of the true man*, or an accession from which it may be separated. Neither does he affirm this only of human souls, but also of all other rational beings whatsoever below the Supreme Deity, that they always naturally actuate some body. Wherefore a demon or angel (which by *Hierocles* are used as synonymous words), is also defined by him after the same manner, ψυχη λογικη μετα φωτεινου σωματος, *a rational soul, together with a lucid body.* And accordingly *Proclus* upon *Plato's Timæus affirmeth*, παντα δαιμονα των ημετερων κρειττονα ψυχων, και νοεραν εχειν, ψυχην, και οχημα αιθεριον: *That every demon, superior to human souls, hath both an intellectual soul and an ethereal vehicle, the entireness thereof being made up or compounded of these two things.* So that there is hardly any other difference between demons or angels, and men, according to these philosophers, but only this, that the former are lapsable into aërial bodies only, and no further; but the latter into terrestrial also. Now, *Hierocles* positively affirms this to have been the true cabala, and genuine doctrine of the ancient Pythagoreans, entertained afterwards by Plato: και τουτο των Πυθαγορειων ἠν δογμα, ὁ δε Πλατων υστερον εξεφηνεν, απεικασας ξυμφυτω δυναμει υποπτερου ξευγους τε και ἡνιοχου; πασαν θειαν τε και ανθρωπινην ψυχην. *And this was the doctrine of the Pythagoreans, which Plato afterwards declared; he resembling every both human and divine soul* (i. e. in our modern language, every created rational being) *to a winged chariot, and a driver or charioteer both together*: meaning by the chariot, an animated body; and by the charioteer, the incorporeal soul actuating it.

That this Pythagorean opinion of the Deity's being the only mind which thinks and acts without material organs was very generally received by the ancient Christians, might be proved by a thousand quotations: We shall content ourselves with producing two from the learned *Origen*. "Solius Dei (saith this philosophic father of the church), id est, Patris, Filii, et Spiritus Sancti, naturæ id proprium est, ut sine materiali substantia, et absque ulla corporeæ adjectionis societate, intelligatur subsistere *." "Materialem substantiam opinione quidem et intellectu solum separari, a naturis rationalibus, et pro ipsis, vel post ipsas affectam videri; sed nunquam sine ipsa eas vel vixisse, vel vivere: Solius namque Trinitatis incorporea vita existere putabitur †." Should Mr Cooper and his friends ask, What is the use of a soul which cannot act without the instrumentality of matter? or why we should suppose the existence of such a substance? we beg leave, in our turn, to ask these gentlemen, What is the use of a brain which cannot see without eyes? and why they should suppose all our sensations to terminate in such an internal system, since the vulgar certainly suppose their sensations to subsist in their respective organs? How this ancient notion, which makes body so essential a part of man, is consistent with the immortality of the human soul, we shall inquire in a subsequent chapter; in which we shall endeavour to ascertain what kind of immortality we have reason to expect, and upon what evidence our expectation must rest. Previous to this inquiry, however, it is necessary to enter upon another, which is of the first importance, and which every materialist has endeavoured to perplex; we mean that which concerns *personal identity*: for if, as has been often said, no man is the same person two days successively, it is of no importance to us whether the soul be mortal or immortal.

* *Peri Archon* lib. 1. cap. 6.

† Lib. 2. cap. 2.

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Chap. III. *Of* Personal Identity.

250 Personal identity,

Whether we are to live in a future state, as it is the most important question which can possibly be asked, so it is the most intelligible one which can be expressed in language. Yet strange perplexities have been raised about the meaning of that identity or sameness of person, which is implied in the notion of our living now and hereafter, or indeed in any two successive moments; and the solution of these difficulties hath been stranger than the difficulties themselves. To repeat all that has been said on the subject would swell this chapter to a disproportionate bulk. We shall therefore content ourselves with laying before our readers the sentiments of Bishop Butler, and the fancies and demonstrations of the philosopher of Manchester. We are induced to adopt this course, because we think the illustrious bishop of Durham has exhausted the subject, by stating fairly the opinions which he controverts, and by establishing his own upon a foundation which cannot be shaken, and which are certainly not injured, by the objections of Mr Cooper.

251 though it cannot be defined, easily understood and ascertained by consciousness and memory.

"When it is asked (says this philosophical prelate*) in what personal identity consists? the answer should be the same as if it were asked in what consists similitude or equality?—that all attempts to define would but perplex it. Yet there is no difficulty at all in ascertaining the idea or notion: For as, upon two triangles being compared or viewed together, there arises to the mind the notion of similitude; or, upon twice two and four, the notion of equality: so likewise, upon comparing the consciousness of one's self or one's own existence in any two moments, there as immediately arises to the mind the notion of personal identity. And as the two former comparisons not only give us the notions of similitude and equality, but also show us that two triangles are similar, and that twice two and four are equal; so the latter comparison not only gives us the notion of personal identity, but also shows us the identity of ourselves in these two moments—the present, suppose, and that immediately past, or the present and that a month, a year, or twenty years past. In other words, by reflecting upon that which is myself now, and that which was myself twenty years ago, I discern they are not two, but one and the same self.

* *Dissertation* 1st, *subjoined to the Analogy of Religion*, &c.

252 These, however, do not make personal identity.

"But though consciousness of what is present and remembrance of what is past do thus ascertain our personal identity to ourselves; yet, to say that remembrance makes personal identity, or is necessary to our being the same persons, is to say that a person has not existed a single moment, nor done one action, but what he can remember; indeed none but what he reflects upon. And one should really think it self-evident, that consciousness of personal identity presupposes and therefore

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fore cannot constitute personal identity; any more than knowledge, in any other case, can constitute truth, which it presupposes.

"The inquiry, what makes vegetables the same in the common acceptation of the word, does not appear to have any relation to this of personal identity; because the word *same*, when applied to them and to person, is not only applied to different subjects, but is also used in different senses. When a man swears to the same tree, as having stood fifty years in the same place, he means only the same as to all the purposes of property and uses of common life, and not that the tree has been all that time the same in the strict philosophical sense of the word: For he does not know whether any one particle of the present tree be the same with any one particle of the tree which stood in the same place fifty years ago. And if they have not one common particle of matter they cannot be the same tree in the proper and philosophic sense of the word *same;* it being evidently a contradiction in terms to say they are, when no part of their substance and no one of their properties is the same; no part of their substance, by the supposition; no one of their properties, because it is allowed that the same property cannot be transferred from one substance to another: And, therefore, when we say that the identity or sameness of a plant consists in a continuation of the same life, communicated under the same organization to a number of particles of matter, whether the same or not; the word *same*, when applied to life and to organization, cannot possibly be understood to signify what it signifies in this very sentence, when applied to matter. In a loose and popular sense, then, the life, and the organization, and the plant, are justly said to be the same, notwithstanding the perpetual change of the parts. But, in a strict and philosophical manner of speech, no man, no being, no mode of being, no any thing, can be the same with that with which it has indeed nothing the same. Now sameness is used in this latter sense when applied to persons. The identity of these, therefore, cannot subsist with diversity of substance.

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What it is.

"The thing here considered, and demonstratively, as I think, determined, is proposed by Mr Locke in these words: *Whether it* (i. e. the same self or person) *be the same identical substance?* And he has suggested what is a much better answer to the question than that which he gives it in form: For he defines a person *a thinking intelligent being*, &c. and personal identity, *the sameness of a rational being;* and then the question is, Whether the same rational being is the same substance? which needs no answer; because being and substance are in this place synonymous terms. The ground of the doubt, whether the same person be the same substance, is said to be this, that the consciousness of our own existence in youth and in old age, or in any two joint successive moments, is not *the same individual action*, i. e. not the same consciousness, but different succesive consciousnesses. Now it is strange that this should have occasioned such perplexities: for it is surely conceivable that a person may have a capacity of knowing some object or other to be the same now which it was when he contemplated it formerly; yet in this case, where, by the supposition, the object is perceived to be the same, the perception of it in any two moments cannot be one and the same perception. And thus, though the successive consciousnesses which we have of our own existence are not the same, yet are they consciousnesses of one and the same thing or object; of the same person, self, or living agent. The person of whose existence the consciousness is felt now, and was felt an hour or a year ago, is discerned to be, not two persons, but one and the same person; and therefore is one and the same.

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False notions of personal identity

"Mr Locke's observations upon this subject appear hasty; and he seems to profess himself dissatisfied with suppositions which he has made relating to it. But some of those hasty observations have been carried to a strange length by others; whose notion, when traced and examined to the bottom, amounts, I think, to this: 'That personality is not a permanent but a transient thing: That it lives and dies, begins and ends, continually: That no one can any more remain one and the same person two moments together, than two successive moments can be one and the same moment: That our substance is indeed continually changing: but whether this be so or not, is, it seems, nothing to the purpose; since it is not substance, but consciousness alone, which constitutes personality; which consciousness, being successive, cannot be the same in any two moments, nor consequently the personality constituted by it*." Hence it must follow, that it is a fallacy upon ourselves to charge our present selves with any thing we did, or to imagine our present selves interested in any thing which befel us yesterday; or that our present self will be interested in what will befal us to-morrow; since our present self is not in reality the same with the self of yesterday, but another self or person coming in its room, and mistaken for it; to which another self will succeed to-morrow. This, I say, must follow: for if the self or person of to-day and that of to-morrow are not the same, but only like persons; the person of to-day is really no more interested in what will befal the person of to-morrow, than in what will befal any other person. It may be thought, perhaps, that this is not a just representation of the opinion we are speaking of; because those who maintain it allow that a person is the same as far back as his remembrance reaches: And indeed they do use the words *identity* and *same* person; nor will language permit these words to be laid aside. But they cannot, consistently with themselves, mean that the person is really the same: For it is self-evident, that the personality cannot be really the same, if, as they expressly assert, that in which it consists is not the same. And as, consistently with themselves, they cannot, so I think it appears they do not, mean that the person is *really* the same, but only that he is so in a fictitious sense, in such a sense only as they assert: for this they do assert, that any number of persons whatever may be the same person. The bare unfolding this notion, and laying it thus naked and open, seems the best confutation of it. However, since great stress is said to be put upon it, I add the following things:

* *Answer to Dr Clarke's third Defence of his Letter to Mr Dodwell*, 2d edit. p. 44. 56, &c.

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overthrown.

"*First*, This notion is absolutely contradictory to that certain conviction, which necessarily and every moment rises within us, when we turn our thoughts upon ourselves, when we reflect upon what is past, and look forward to what is to come. All imagination, of a daily change of that living agent which each man calls himself

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self for another, or of any such change throughout our whole present life, is entirely borne down by our natural sense of things. Nor is it possible for a person in his wits to alter his conduct with regard to his health or affairs, from a suspicion that though he should live to-morrow he should not however be the same person he is to-day.

" *Secondly*, It is not an *idea* or abstract *notion*, or quality, but a being only, which is capable of life and action, of happiness and misery. Now all beings confessedly continue the same during the whole time of their existence. Consider then a living being now existing, and which has existed for any time alive: this living being must have done, and suffered, and enjoyed, what it has done, and suffered, and enjoyed, formerly (this living being, I say, and not another), as really as it does, and suffers, and enjoys, what it does, and suffers, and enjoys, this instant. All these successive actions, sufferings, and enjoyments, are actions, enjoyments, and sufferings, of the same living being; and they are so prior to all considerations of its remembering or forgetting, since remembering or forgetting can make no alteration in the truth of past matter of fact. And suppose this being endued with limited powers of knowledge and memory, there is no more difficulty in conceiving it to have a power of knowing itself to be the same being which it was some time ago, of remembering some of its actions, sufferings, and enjoyments, and forgetting others, than in conceiving it to know, or remember, or forget, any thing else.

" *Thirdly*, Every person is conscious that he is now the same person or self he was as far back as his remembrance reaches: since when any one reflects upon a past action of his own, he is just as certain of the person who did that action, namely himself (the person who now reflects upon it), as he is certain that the action was at all done. Nay, very often a person's assurance of an action having been done, of which he is absolutely assured, arises wholly from the consciousness that he himself did it: and this he, person or self, must either be a substance or the property of some substance. If *he*, if person, be a substance; then consciousness that he is the same person, is consciousness that he is the same substance. If the person, or *he*, be the property of a substance, still consciousness that he is the same property is as certain a proof that his substance remains the same, as consciousness that he remains the same substance would be; since the same property cannot be transferred from one substance to another.

" But though we are thus certain that we are the same agents, living beings, or substances, now, which we were as far back as our remembrance reaches; yet it is asked, Whether we may not possibly be deceived in it? And this question may be asked at the end of any demonstration whatever; because it is a question concerning the truth of perception by memory: and he who can doubt whether perception by memory can in this case be depended upon, may doubt also whether perception by deduction and reasoning, which also include memory, or indeed whether intuitive perception itself, can be depended upon. Here then we can go no farther: for it is ridiculous to attempt to prove the truth of our faculties, which can no otherwise be proved than by the use or means of those suspected faculties themselves."

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256 Objection to the foregoing reasoning.

This reasoning, which we believe will to most men appear unanswerable, Mr Cooper hopes to overturn by the following observations *: " If all imagination of a daily change in us be borne down by our natural sense of things, then (says he) does our natural sense of things positively contradict known fact; for a daily, a momentaneous, change in us, i. e. in our bodies, does actually take place." True, a daily change in our bodies does take place, and so likewise does a daily change in our clothes; but surely no man was ever led by his natural sense of things to suppose, that his limbs or external organs were the seats of sensation and will, any more than that his coat or his shoes were any real parts of his trunk or of his feet. But it is only that which thinks and wills that any man considers in this case, as himself or his person; and if our natural sense of things, or consciousness, tell us, that what thinks and wills has continued the same from a distance of time as far back as we can remember, it is certain, that whether it be material or immaterial, it has continued from that period, otherwise we can be certain of nothing. " But (says our philosopher) other known and ascertained facts are frequently borne down by our natural sense of things: for how many thousand years before the days of *Copernicus* was the motion of the earth round the sun entirely borne down by our natural sense of things, which made us give full credit to the motion of the sun round the earth? Do not the generality of mankind believe, upon the evidence of their natural sense of things, that every part of their body remains exactly the same to-day as it was yesterday?"

* *Tracts*, &c.

257 Answered.

To the former of these questions we answer positively, that before the days of *Copernicus* the motion of the earth round the sun was *not* borne down by our *natural sense* of things, but by ill-founded hypotheses and inconclusive reasonings. By the natural sense of things, nothing can be meant, in this place, but the evidence of consciousness or of external sensation; but the *actual motion* either of the sun or of the earth is not perceived either by consciousness or by sensation. Of consciousness nothing is the object but the internal energies and feelings of our own minds; and with regard to the motion of the sun or of the earth, nothing is perceived by the sense of sight but that, after considerable intervals of time, these two great bodies have repeatedly changed their places in the heavens with respect to each other. This is all that on this subject our *natural sense of things* leads us to believe; and is not this infallibly true? Afterwards indeed, by taking for granted the truth of proposisions, for which neither sense nor consciousness affords the shadow of evidence; the vulgar now, and all mankind formerly, reasoned themselves into the opinion, that the earth stands still, and that the sun moves round it. In vulgar philosophy it is taken for granted, that in the universe there is not a *relative* but an *absolute upwards* and an *absolute downwards*; that our heads are absolutely upward, and our feet downward; and that were the earth to revolve round its axis; these positions would be reversed, that our heads would be placed beneath our feet, and that we ourselves would fall from the earth into

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into empty space. Upon these false hypotheses the vulgar reason correctly. They know that bodies cannot change their place without motion; they know that in the time of their remembrance the sun and the earth have been perpetually varying their places with respect to each other; they know that they themselves have never fallen, nor had a tendency to fall, into empty space; and hence they infer that it is the sun and not the earth that moves (K). But will any man say that the absurd suppositions from which this conclusion is logically deduced, have the evidence either of sensation or of consciousness, as the permanency of that living agent which each man calls himself has?

To our author's second question we likewise reply with confidence, that the generality of mankind do *not* believe, upon their natural sense of things, that every part of their body remains exactly the same to-day as it was yesterday. It would be strange indeed if they did, after having repeatedly experienced the waste of increased perspiration or sweating; after having witnessed men emaciated by sickness, and again restored to plumpness in health; and after having perhaps lost whole limbs, which certainly their natural sense of things teaches them to consider as parts of their body. In all these cases, the generality of mankind are as sensible of changes having taken place in their bodies as he who has attended ever so closely to physiological inquiries, though not one of them has the least imagination of a change having taken place in the living agent which each man calls himself.

Bishop Butler observes, that if the living agent be perpetually changing, it is a fallacy upon ourselves to charge our present selves with any thing we did, to imagine our present selves interested in any thing which befel us yesterday, or that our present self will be interested in what will befal us to-morrow. To this judicious observation our daring philosopher replies, "that as the man of to-morrow, though not in all points the same with, yet depends for his existence upon, the man of to-day, there is sufficient reason to care about him." Could he have said that as the man of to-day depends for his existence on the man of to-morrow, there is sufficient reason for the present man to care about the future man; or that as the man of to-morrow depends for his existence on the man of to-day, there is to-day sufficient reason for the future man to care about the present man; we should in either case, if the anachronism had been kept out of sight, have seen the force of his argument. Every man has sufficient reason to care about the ox upon which he is to be fed; but we cannot so clearly perceive what reason the ox has to care about the man.

Not satisfied, it would seem, with this reply, our author proceeds to affirm, "that the man of to-morrow, possessing a reminiscence of the actions of the man of to-day, and knowing that these actions will be referred to him both by himself and others (which is certainly knowing that both himself and others are most iniquitous wretches), they cannot be indifferent to the man of to-day, who looks forward to the properties of the man of to-morrow;" i. e. the reminiscence and knowledge of a future man constitute all the relation that subsist between a present man and his actions; a discovery worthy of an original genius. But as on the subject of personal identity we pretend to no originality, we shall leave this proposition to the meditation of our readers, and take the liberty to ask our author a question or two respecting this same reminiscence, which he is graciously pleased to acknowledge for a property.

He defines identity, "the continued existence of any being unaltered in substance or in properties;" and he repeatedly acknowledges that no identical quality or property can be transferred from one subject to another. Let us now suppose, that a man has a reminiscence of an individual action performed a month ago, and that this reminiscence is accompanied with a consciousness that the action was performed by himself. This supposition, whether true or false, may certainly be made; for it implies nothing more than what every man firmly believes of himself in every act of remembrance. Let us again suppose, that, at the distance of ten or twenty years, the man known by the same name has a reminiscence of the same action, with a consciousness that he himself performed it. Is this reminiscence the same with the former? or is it a different reminiscence? If it be the same, either the person remembering at the distance of ten or twenty years is the same with him who remembered at the distance of a month, or there is an identical quality transferred from one substance to another, which is admitted to be impossible. If reminiscence be itself a real and immediate quality of any substance, and not the mere energy of a power, and if the one reminiscence be different from the other, the subjects in which these two different qualities inhere must likewise be different. Yet the man who has the reminiscence at the distance of a month, has the evidence of consciousness that the action was performed by him; and the man who has the reminiscence at the distance of ten or twenty years, has likewise the evidence of consciousness that the same action was performed by him and not by another. By the confession of Hume and of all philosophers, consciousness never deceives; but here is the evidence of one consciousness in direct opposition to another; and therefore, as two contradictory propositions cannot both be true, either the one reminiscence is the same with the other, or reminiscence is no real quality. That one act of reminiscence should be numerically the same with another, which followed it at the distance of twenty years, is plainly impossible; whence it should seem, that reminiscence itself is no real and immediate quality of any substance. But if this be so, what is reminiscence? We answer, it is plainly neither more nor less than the *energy* of a power, which

(K) This inference too has been so often drawn, that it comes in time to coalesce in the mind with the *sensations*, from which the motion either of the sun or of the earth is deduced with infallible certainty; and hence it is considered as part of that truth which sensation immediately discovers. *See our chapter of Association.*

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which though dormant between its energies, remains unchanged from the one to the other, and which being itself the real and immediate quality of a subject, that subject must likewise remain unchanged. That powers may remain dormant, and yet unchanged, every man must be convinced; who having struck any thing with his hand, knows that he has power to repeat the stroke, and yet does not actually repeat it. Two blows with the hand immediately following each other are numerically different, so that the one cannot with truth be said to be the other; but we have the evidence of external sense, that they are both struck by the same member. In like manner, two energies of reminiscence directed to the same object, and succeeding each other at any interval of time, cannot possibly be one and the same energy; but as the latter energy may include in it the former as well as the object remembered by both, we have the evidence of consciousness that both are energies of the same power; and we have seen, that to suppose them any thing else, may be demonstrated to involve the grossest absurdities and contradictions.

Mr Cooper has other arguments to obviate the force of Bishop Burnet's demonstration of personal identity; such as, that a "high degree of *similarity* between the two succeeding men is sufficient to make the one care about the other; and, that "a good man, knowing that a future being will be punished or rewarded as the actions of the present man deserve, will have a sufficient motive to do right and to abstain from wrong." But if there be any one of our readers who can suffer himself to be persuaded by such assertions as these, that the living agent which he calls himself is perpetually changing, and at the same time that such change is consistent with the expectation of future rewards and punishments, he would not be reclaimed from his error by any reasoning of ours. We shall therefore trust such trifling with every man's judgment, and proceed to examine our author's *demonstration*, that personal identity has no existence. But here it is no part of our purpose to accompany him through his long chemical ramble, or to controvert his arguments for the nonidentity of vegetable and animal bodies. The only thing to which, after Bishop Butler, we have ascribed identity, is that which in man is sentient and conscious; and the nonidentity of this thing, whatever it be, Mr Cooper undertakes to demonstrate from the known properties of sensations and ideas.

258 A pretended demonstration that personal identity is impossible.

This demonstration sets out with a very ominous circumstance. The author, after conducting impressions *ab extra*, from the extremities of the nerves to the brain, affirms, that *sensations* and *ideas* are nothing but "motions in the brain perceived;" i. e. when a man thinks he is looking at a mountain, not only at rest, but to appearance immoveable, he is grossly deceived: for he perceives nothing all the while but *motion in his brain!* Were not the desire of advancing novelties and paradoxes invincible in some minds, we should be astonished at finding such an assertion as this fall from the pen of any man who had paid the slightest attention to the different energies of his own intellect. Motions in the brain, as we have repeatedly observed, are the immediate causes of our sensations; but is it conceivable, is it possible, that any thing should be the cause of itself? The motion of a sword through the heart of a man, is the immediate cause of that man's death; but is the sword or its motion *death* itself, or can they be conceived as being the *sensations* of the *man* in the *agonies* of *dying*? But sensations and ideas, whatever they be, exist in succession; and therefore, argues our demonstrator, no two sensations or ideas can be one and the same sensation or idea. The conclusion is logically inferred; but what purpose can it possibly serve? What purpose! why it seems "sensations and ideas are the only *existences whose existence* we certainly know (a charming phrase, the *existence* of *existences*, and as original as the theory in which it makes its appearance); and, therefore, from the nature of sensations and ideas there is no such thing as permanent identity." Indeed! what then, we may be permitted to ask, is the import of the word *we* in this sentence? Does it denote a series of sensations and ideas, and does each sensation and each idea certainly know not only itself, but all its ancestors and all its descendants? Unless this be admitted, we are afraid that some other existence besides sensations and ideas must be allowed to be certainly known, and even to have something of a permanent identity. Nay, we think it has been already demonstrated (see Chapter of TIME), that were there not something permanent, there could be no time, and of course no notion of a first and last, or indeed of succession, whether of sensations or ideas. And therefore, if we have such a notion, which the author here takes for granted, and upon which indeed his demonstration rests, it follows undeniably that there is something permanent, and that we *know* there is something permanent, which observes the succession of sensations and ideas.

259 Shown to be absurd and ridiculous.

All this, indeed, Mr Cooper in effect grants; for he is not much startled at the appearance of contradictions in his theory. "I find (says he), by perpetually repeated impressions which I perceive, that my hands, body, limbs, &c. are connected, are parts of one whole. I find, by perpetually repeated perceptions also, that the sensations excited by them are constantly similar, and constantly different from the sensations excited by others." He has then repeated perceptions: but how can this be possible, if *he* be not different from the perceptions, and if *he* do not *remain unchanged* while the perceptions succeed each other at greater or less intervals of time? A striking object passing with rapidity before the eyes of a number of men placed beside each other in a line of battle, would undoubtedly excite a succession of sensations; but surely that succession would not take place in the mind of *any individual* in the line, nor could any *single man* in this case say with truth that he had *repeated* perceptions of the object. In like manner, were that which is sentient perpetually changing, no man could possibly say or suppose that he had repeated perceptions of any thing; for upon this supposition, the man of to-day would have no more connexion with the man who bore his name yesterday, or twenty years ago, than the man in the line had with the first.

Upon the whole, we cannot help thinking that Bishop Butler's demonstration of personal identity remains unshaken by the batteries of Mr Cooper.—It rests, indeed,

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deed, upon the solid basis of consciousness and memory; and if implicit credit be not given to the evidence of these faculties, we cannot proceed a single step in any inquiry whatever, nor be certain of the truth even of a mathematical demonstration.

260 A difficulty removed.

But as we have ourselves supposed, that to sensation, reminiscence, and every actual energy of the mind of man, the instrumentality of some material system is necessary, it may perhaps be thought incumbent on us to show how the perpetual flux of the particles of matter which compose the brain, as well as all the other parts of the body, can consist with the identity of the person who perceives, remembers, and is conscious. If this cannot be done, our hypothesis, ancient and plausible as it is, must be given up; for of personal identity it is impossible to doubt. In this case, however, we perceive no difficulty; for if there be united to the brain an immaterial being, which is the subject of sensation, consciousness, and will, &c. it is obvious, that all the *intellectual powers* which properly constitute the person, must be inherent in that being. The material system, therefore, can be necessary only as an instrument to excite the energies of those powers; and since the powers themselves remain unchanged, why should we suppose that their energies may not be continually exerted by successive instruments of the same kind, as well as by one permanent instrument? the powers of perception and volition are not in the material system, any more than the sensation of seeing is in the rays of light, or the energy of the blacksmith in the hammer with which he beats the anvil. Let us suppose a man to keep his eye for an hour steadily fixed upon one object. It will not surely be denied, that if this could be done, he would have one uninterrupted and unvaried perception of an hour's duration, as measured by the clock. Yet it is certain that the rays of light which alone could occasion that perception would be perpetually changing. In like manner, a blacksmith, whilst he continues to beat his anvil, continues to exert the same power whether he uses one hammer all the time, or a different hammer at each stroke. The reason is obvious; the eye, with all its connexions of brain and mind in the one case, and the person of the smith in the other, remain unchanged; and in them alone reside the faculty of sensation and the power of beating, though neither the faculty nor the power can be exerted without material instruments. But were it possible that millions of men could in the space of an hour take their turns in rotation with each new ray of light, it is self-evident, that in this case, there would be nothing permanent in sensation; and therefore, there could not be one uninterrupted and unvaried perception, but millions of perceptions, during the hour, totally distinct from and unconnected with each other. Let us now suppose a man to fix his eye upon an object for the space of a minute, and at the distance of a day or a month to fix it upon the same object a second time. He could not indeed, in this case have one uninterrupted and unvaried perception, but he would be conscious of the energy of the very same faculty the second time as at the first. Whereas were one man to view an object to-day, and another to view the same object to-morrow, it is obvious, that he who should be last in the succession could know nothing of the energy of that faculty by which the object was perceived the first day, because there would be nothing common to the two perceptions.

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Thus then we see, that *personal identity* may with truth be predicted of a compound being, though the material part be in a perpetual flux, provided the immaterial part remain unchanged; and that of such a being only is a resurrection from the dead possible.—For since the motions of the brain do nothing more than excite to energy the permanent powers of the mind, it is of no sort of consequence to that energy whether these motions be continued by the same numerical atoms, or by a perpetual succession of atoms arranged and combined in the very same manner. We shall, therefore, be the same persons at the resurrection as at present, whether the mind be united to a particular system composed of any of the numberless atoms which have in succession made parts of our present bodies, or to a system composed of totally different atoms, provided that new system be organized in exactly the same manner with the brain or material vehicle, which is at present the immediate instrument of perception. This (we say) is self-evident; but were the immaterial part to change with the changing body, a resurrection of the same persons would be plainly impossible.

Chap. IV. *Of the* Immortality *of the* Soul.

261 The immortality of the soul the general belief in all nations.

Wherever men have been in any degree civilized, and in some nations where they have been in the most savage state, it has been the general persuasion, that the mind or soul subsists after the dissolution of the body. The origin of this persuasion, about which disputes have been raised, no Christian hesitates to attribute to revelation. The Egyptians, from whom the Greeks derived many of their theological and philosophical principles, appear to have taught the immortality of the soul, not as a truth discovered by the exertions of human reason, but as a dogma derived to them from the earliest ages by tradition. This indeed may be confidently inferred from the character and conduct of their first Greek disciples. Those early wise men who fetched their philosophy immediately from Egypt, brought it home as they found it, in detached and independent placits. Afterwards, when schools were formed, and when man began to philosophize by hypothesis and system, it was eagerly inquired upon what foundation in *nature* the belief of the soul's immortality could rest; and this inquiry gave rise to the various disquisitions concerning the *substance* of the soul, which have continued to exercise the ingenuity of the learned to the present day. It was clearly perceived, that if consciousness, thought, and volition, be the result of any particular modification of matter and motion, the living and thinking agent must perish with the dissolution of the system; and it was no less evident, that if the being which perceives, thinks, and wills, be not material, the mind of man *may* subsist after the resolution of the body into its component particles. The discovery of the immateriality of the mind was therefore one *step towards* the proof of its immortality; and in the opinion of many philosophers, whose hopes ought to rest on a surer basis, it was alone a complete proof.—"They who hold sensitive perception in brutes (says a pious writer)

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writer *) to be an argument for the immateriality of their souls, find themselves under the necessity of allowing those souls to be immortal."

* See the Procedure, Extent, and Limits of the Understanding.

262 The philosophers of ancient Greece believed likewise in its pre-existence

The philosophers of ancient Greece, however, felt not themselves under any such necessity. Whatever were their opinions respecting the souls of brutes, they clearly perceived that nothing which had a beginning of existence could be naturally immortal, whether its substance were material or immaterial.—" There never was any of the ancients before Christianity (says the accurate Cudworth), that held the soul's future permanency after death, who did not likewise assert its pre-existence; they clearly perceiving, that if it were once granted that the soul was generated, it could never be proved but that it might be also corrupted. And, therefore, the assertors of the soul's immortality commonly began here, first to prove its pre-existence, proceeding thence to establish its permanency after death. This is the method of proof used in Plato: Ην που ἡμων ἡ ψυχη πριν εν τω δε τω ανθρωπινω ειδει γενεσθαι, ὡστε και ταυτη αθανατον τι εοικεν ἡ ψυχη ειναι. *Our soul was somewhere before it came to exist in this human form, and thence it appears to be immortal, and as such will subsist after death.*

263 and absolute eternity.

To give this argument for immortality any strength, it must be taken for granted, not only that the soul existed in a *prior* state, but that it existed from all *eternity*; for it is obvious, that if it had a beginning in any state, it may have an end either in that state or in another. Accordingly, Plato asserts in plain terms its eternity and self-existence, which, as we learn from Cicero, he infers from its being the principle of motion in man. " Quin etiam cæteris, quæ moventur, hic fons, hoc principium est movendi. *Principii autem nulla est origo.* Nam ex principio oriuntur omnia: ipsum autem nulla ex re alia nasci potest: nec enim esset id principium, quod gigneretur aliunde †." This, it must be acknowledged, is very contemptible reasoning; but the opinion which it was intended to prove was held by all the philosophers. They were unanimous in maintaining the *substance* of the soul, though not its *personality*, to be eternal *à parte ante* as well as *ad partem post*; and Cicero, where he tells us that this opinion passed from *Pherecydes Syrus* to Pythagoras, and from Pythagoras to *Plato*, expresses their notion of the soul's duration by the word *sempiternus* ‡, which, in its original and proper sense, is applicable only to that which has neither beginning nor end.

† *Tuscul.* lib. i. cap. 23.

‡ *Tuscul.* lib. i.

Indeed none of the philosophers of ancient Greece appear to have believed a creation (see CREATION) possible: for it was a maxim universally received among them, *De nihilo nihil fit, in nihilum nil posse reverti*; that *nothing can come from nonentity, or go to nonentity.* This maxim, as held by the theistical philosophers, the learned Cudworth labours to interpret in a sense agreeable to our notions of the origin of the world; but the quotations urged by himself must convince every competent reader that on this occasion he labours in vain. For instance, when Aristotle writes of Parmenides and Melissus, that ουδεν ουδε γινεσθαι φασιν ουδε φθειρεσθαι των οντων, *they say that no real entity is either made or destroyed*; what can be his meaning, but that those philosophers taught that nothing could be either created or annihilated? He testifies the same thing of *Xenophanes* and *Zeno*, when he says that it was a fundamental principle of their philosophy—μη ενδεχεσθαι γινεσθαι μηδεν εκ μηδενος—*that it is impossible that any thing should be made out of nothing.* And of Empedocles, when he relates απαντα ταυτα κακεινος ὁμολογει ὁτι εκ τε μη οντος αμηχανον εστι γινεσθαι το τε ον εξολλυσθαι ανηνυστον και αρρηκτον—*That he acknowledges the very same thing with other philosophers*, viz. *that it is impossible that any thing should be made out of nothing, or perish into nothing.* But it is needless to multiply quotations respecting the opinions of single philosophers. Of all the physiologers before himself and Plato, Aristotle says, without exception, περι ταυτης ὁμογνωμονουσι της δοξης οἱ περι φυσεως, ὁτι το γιγνομενον εκ μη οντων γιγνεσθαι αδυνατον †—*That they agree in this opinion, that it is impossible that any thing should be made out of nothing*: and he calls this the common principle of naturalists; plainly intimating, that they considered it as the greatest absurdity to suppose that any real entity in nature could either be brought from nothing or reduced to nothing.

† *Physic.* lib. i. cap. 5.

The author of the *Intellectual System*, in order, perhaps, to hide the impiety of this principle, endeavours to persuade his readers, that it was urged only against the hypothesis of forms and qualities of bodies considered as real entities, distinct from matter. But how it could be supposed to militate against that particular opinion, and not against the possibility of all creation, is to us perfectly inconceivable. The father of the school which analyzed body into matter and form, together with by far the greater part of his followers, taught the eternity of both these principles (L); and therefore maintained, as strenuously as any atomist, the universal maxim, *De nihilo nihil fit.* Even Plato himself, whose doctrine of *ideas* is supposed to wear a more favourable aspect than Aristotle's *forms* to the truths of revealed religion, taught the *eternity* of *matter*; but whether as a self-existing substance, or only as an emanation from the Deity, is a question which has

(L) *Aristotelem*, et plerosque Peripateticorum, in vulgus notum est, in hac fuisse sententia—nec *natum* esse, nec *interiturum* unquam hunc mundum. Vid. *PETRUS GASSENDUS Physic.* sect. i. lib. i. cap. 6. *JAC. THOMASIUS de Stoica mundi exustione.* Diss. 4. et alii. Plures ita haud dubie senserunt philosophorum veterum. Hinc video *MANILIUM* in *Astronomico*, lib. i. inter philosophorum de mundo sententias hanc, ac si præcipua esset, primo commemorare loco:

Quem sive ex nullis repetentem semina rebus,
NATALI QUOQUE EGERE placet, semperque FUISSE,
ET FORE, PRINCIPIO pariter FATOQUE carentem.

Mosheim's edition of Cudworth's Intellectual System, lib. i. cap. 3. sect. 33. note 60. On this subject see also *Ancient Metaphysics.*

has been disputed. That he admitted no proper creation, may be confidently inferred from Plutarch; who, writing upon the generation of animals, according to the doctrine laid down in the *Timæus*, has the following passage: Βελτιον ουν, Πλατωνι πειθομενους τον μεν κοσμον ὑπο θεου γεγονεναι λεγειν και αδειν· ὁ μεν γαρ καλλιςος των γεγονοτων ὁιδε αριςος των αιτιων την δε ΟΥΣΙΑΝ και ΥΛΗΝ εξ ης γεγονεν ου γενομενην, αλλα ὑποκειμενην αει τω δημιουργω εις διαθεσιν και ταξιν αυτης, και προς εξομοιωσιν, ὡς δυνατον ην παρασχειν· ου γαρ εκ του μη οντος ἡ γενεσις, αλλ' εκ του μη καλως, μηδ' ικανως εχοντος, ὡς οικιας και ἱματιον, και ανδριαντος *. *It is therefore better for us to follow Plato, and to say and sing that the world was made by God. For as the world is the best of all works, so is God the best of all causes. Nevertheless, the* SUBSTANCE OR MATTER *out of which the world was made, was* NOT *itself made, but was always ready at hand, and subject to the artificer, to be ordered and disposed by him. For the making of the world was not the production of it out of nothing, but out of an antecedent bad and disorderly state, like the making of a house, garment, or statue.*

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* Plut. Op. t. ii. p. 1014.

If, then, this be a fair representation of the sentiments of Plato, and surely the author understood those sentiments better than the most accomplished modern scholar can pretend to do, nothing is more evident, than that the founder of the academy admitted of no proper creation, but only taught that the matter which had existed from eternity in a chaotic state, was in *time* reduced to order by the *Demiurgus* or Supreme Being. And if such were the sentiments of the divine Plato, we cannot hesitate to adopt the opinion of the excellent Mosheim, which the reader will probably be pleased to have in his own words: "Si à Judæis discedas, nescio an ullus antiquorum philosophorum mundum negaverit æternum esse. Omnes mihi æternum professi videntur esse mundum: hoc uno vero disjunguntur, quod nonnulli ut *Aristoteles*, *formam* et *materiam* simul hujus orbis, alii vero, quorum princeps facile Plato, *materiam* tantum *æternam*, formam vero, à Deo comparatam, dixerunt †."

† Notes on Cudworth's Intellectual System.

Now, it is a fact so generally known, as not to stand in need of being proved by quotations, that there was not among them a single man who believed in the existence of mind as a being more excellent than matter, and essentially different from it, who did not hold the superior of at least equal antiquity with the inferior substance. So true is this, that Synesius, though a Christian, yet having been educated in one of the schools of philosophy, could not, by the hopes of a bishopric, be induced to dissemble this sentiment: αμελει την ψυχην ουκ αξιωσω ποτε σωματος ὑςερογενη νομιζειν ‡. —*I shall never be persuaded to think my soul younger than my body.* This man probably believed, upon the authority of the scriptures, that the matter of the visible world was created in time; but he certainly held with his philosophic masters, that his own soul was as old as any atom of it, and that it had consequently existed in a prior state before it animated his present body.

‡ Epist. 105.

264 They supposed all souls to be emanations from the first mind;

Those who maintained that the world was uncreated, maintained upon the same principle that their souls were uncreated likewise; and as they conceived all bodies to be formed of one first matter, so they conceived all souls to be either emanations from the one first Mind, or discerpted parts of it. Aristotle, who distinguishes between the intellectual and sensitive souls, says expressly of the former, that it "enters from without, and is DIVINE;" adding this reason for his opinion, that "its energy is not blended with that of the body—λειπεται δε τον νουν μονον θυραθεν επεισιεναι, και θειον ειναι μονον· ουδε γαρ αυτου τη ενεργεια κοινωνει σωματικη ενεργεια *. As to the Stoics, *Cleanthes* held (as Stobæus informs us †), that "every thing was made out of one, and would be again resolved into one." But let Seneca speak for them all: "Quid est autem, cur non existimes in eo *divini* aliquid existere, qui DEI PARS est? Totum hoc, quo continemur, et unum est, et Deus: et socii ejus sumus, et membra ‡—*Why should you not believe something to be divine in him, who is indeed* PART OF GOD? *That* WHOLE *in which we are contained is* ONE, *and that one is* GOD; *we being his companions and* MEMBERS. Epictetus says, *The souls of men have the nearest relation to God, as being* PARTS OR FRAGMENTS *of him,* DISCERPTED *and* TORN *from his* SUBSTANCE; συναφεις τω θεω, ἁτε αυτου μορια ουσαι και αποσπασματα. Plato writes to the very same purpose, when, without any softening, he frequently calls the soul *God*, and *part of God*. And Plutarch says, that "Pythagoras and Plato held the soul to be immortal; for that, launching out into the soul of the universe, it returns to its parent and original—Πυθαγορας, Πλατων, ἀφθαρτον ειναι την ψυχην· εξιουσαν γαρ εις την του παντος ψυχην, αναχωρειν προς το ομογενες ||." Plutarch declares his own opinion to be, that "the soul is not so much the work and production of God, as a PART of him; nor is it made BY him, but FROM him, and OUT of him: ἡ δε ψυχη ουκ εργον εςι μονον, αλλα και μερος· ουδ' ΥΠ' αυτου, αλλ' ΑΠ' αυτου, και ΕΞ αυτου γεγονεν §." But it is needless to multiply quotations. Cicero delivers the common sentiments of his Greek masters on this head, when he says ¶, "A natura deorum, ut doctissimis sapientissimisque placuit, HAUSTOS animos et LIBATOS habemus." And again: "Humanus autem animus DECERPTUS EX MENTE DIVINA: cum alio nullo, nisi cum ipso Deo (si hoc fas est dictu), comparari potest."

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* De Generatione Animalium, lib. ii. cap. 3.

† Eclog. Phys. c. 20.

‡ Epist. 92.

|| De Placitis Philosophorum, lib. iv. cap. 7.

§ Plato Quæst.

¶ De Divinatione, lib. i. cap. 49.

265 But differed in opinion as to the mode of their separation.

Whilst the philosophers were thus unanimous in maintaining the soul to be a part of the self-existent Substance, they differed in opinion, or at least expressed themselves differently, as to the mode of its separation from its divine parent. Cicero and the Stoics talk as if the Supreme Mind were extended, and as if the human soul were a part literally torn from that mind, as a limb can be torn from the body. The Pythagoreans and Platonists seem to have considered all souls as emanations from the divine Substance rather than as parts torn from it, much in the same way as rays of light are emanations from the sun. Plato, in particular, believed in two self-existent principles, God and matter. The former he considered as the supreme Intelligence, incorporeal, without beginning, end, or change; and distinguished it by the appellation of το αγαθον, *the Good*. Matter, as subsisting from eternity, he considered as without any one *form* or *quality* whatever, and as having a natural tendency to disorder. Of this chaotic mass God formed a perfect world, after the eternal pattern in his own mind, and endowed it with a soul or emanation from himself. In the language of Plato, therefore, the universe being animated by a soul which proceeds from God, is called the *son of God*; and

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and several parts of nature, particularly the heavenly bodies, are *gods*. The human soul, according to him, is derived by emanation from God, through the intervention of this soul of the world; and receding farther from the first intelligence, it is inferior in perfection to the soul of the world, though even that soul is debased by some material admixture. To account more fully for the origin and present state of human souls, Plato supposes *, that "when God formed the universe, he separated from the soul of the world inferior souls, equal in number to the stars, and assigned to each its proper celestial abode; but that those souls, (by what means, or for what reason, does not appear), were sent down to the earth into human bodies, as into sepulchres or prisons." He ascribes to this cause the depravity and misery to which human nature is liable; and maintains, that it "is only by disengaging itself from all animal passions, and rising above sensible objects, to the contemplation of the world of intelligence, that the soul of man can be prepared to return to its original state." Not inconsistently with this doctrine, our philosopher frequently speaks of the soul of man as consisting of three parts: or rather he seems to have thought that man has three souls; the first the principle of intelligence, the second of passion, and the third of appetite (M); and to each he assigns its proper place in the human body. But it was only the intellectual soul that he considered as immortal.

* *Enfield's Abridgement of Brucker's History of Philosophy.*

Aristotle taught, in terms equally express, that the human soul is a part of God, and of course that its substance is of eternal and necessary existence. Some of his followers, indeed, although they acknowledged *two first principles*, the active and the passive, yet held, with the Stoics, but *one substance* in the universe; and to reconcile these two contradictory propositions, they were obliged to suppose matter to be both active and passive. Their doctrine on this subject is thus delivered by Cicero: "De natura ita dicebant, ut eam dividerent in res duas, ut altera esset efficiens, altera autem quasi huic se præbens, ea quæ efficeretur aliquid. In eo, quod efficeret, vim esse censebant; in eo autem quod efficeretur, materiam quandam; in UTROQUE TAMEN UTRUMQUE. Neque enim materiam ipsam cohærere potuisse, si nulla vi contineretur, neque VIM SINE ALIQUA MATERIA; nihil est enim, quod non alicubi esse cogatur †." *They divided nature into two things, as the first principles; one whereof is the efficient or artificer, the other that which offers itself to him for things to be made out of it. In the efficient principle, they acknowledged active force; in the passive, a certain matter; but so, that in* EACH BOTH OF THESE WERE TOGETHER: *forasmuch as neither the matter could cohere together unless it were contained by some active force, nor* THE ACTIVE FORCE SUBSIST OF ITSELF WITHOUT MATTER; *because that is nothing which may not be compelled to be somewhere.* Agreeably to this strange doctrine, Arrian, the interpreter of Epictetus, says of himself, ειμι ανθρωπος, μερος των παντων, ὡς ὡρα ἡμερας, "I am a man (a part of the το παν or *universe*), as an hour is part of the day."

† *Academicum*, lib. 1. cap. 6.

Aristotle himself is generally supposed to have believed in the eternal existence of two substances, *mind* and *matter*; but treating of the generation of animals, he says, ενδε το παντι θερμοτης ψυχικη, ως τροπον τινα παντα ψυχης ειναι πληρη διο συνισταται ταχεως ὁποταν εμπεριληφθη ‡. *In the universe there is a certain animal heat, so as that after a manner all things are full of mind; wherefore they are quickly completed (or made complete animals) when they have received a portion of that heat.* This *heat*, from which, according to Cicero ||, the Stagyrite derived all souls, has, it must be confessed, a very material appearance; insomuch that the learned Mosheim seems to have been doubtful whether he admitted of any immaterial principle in man; but for this doubt there appears to us to be no solid foundation. Aristotle expressly declares, that *this heat is not fire* nor any *such power, but a spirit which is in the seeds* or *elementary principles of bodies*; τουτο δε ου πυρ, ουδε τοιαυτη δυναμις εστιν, αλλα το εμπεριλαμβανομενον εν τω σπερματι και εν τω αφρωδει πνευμα §. And as the excellent person himself acknowledges (N), that Aristotle taught the existence of two principles, God and matter, not indeed subsisting

‡ *De Generatione Animalium*, lib. iii. cap. 11.

|| *Tuscul.* lib. i. c. 3.

§ *De Generatione Animalium*, lib. ii. c. 3.

(M) "Plato triplicem finxit animam; cujus principatum, id est, rationem, in capite, sicut in arce, posuit: et duas partes separare voluit, iram et cupiditatem, quas locis disclusit; iram in pectore, cupiditatem subter præcordia locavit." *Ciceronis Tusc. Quest.* lib. i. cap. 10.

This hypothesis has been adopted by the learned author of Ancient Metaphysics: but it cannot be proved by argument, and is in direct opposition to consciousness. Were there three distinct minds in each man—the principles of intelligence, of passion, and of appetite, it is obvious that *each man* would be *three persons*, and that *none* of these persons could know any thing of the powers and properties of the *other two*. The intelligent person could not reason about *passion* or *appetite*: nor could the persons who know nothing but passion and appetite reason about *intelligence*, or indeed about any thing else. The very question at issue, therefore, furnishes the most complete proof possible, that the same individual which each man calls himself, is the principle of intelligence, of passion, and of appetite; for if the Platonic hypothesis were true, that question could never have been started, as no one individual of the human race could have understood all its terms. It may be just worth while to mention, that the author of Ancient Metaphysics, attributing all motion, and even the coherence of the minute particles of body, to the immediate agency of mind, of course furnishes every human body with at least *four minds*. This fourth mind differs not from the *plastic nature* of Cudworth, and is likewise a Platonic notion apparently better founded. That there are in our bodies motions perpetually carried on by the agency of something which is not the principle of either our intelligence, our passions, or our appetites, is a fact which cannot be denied; but if those motions proceed immediately from mind, it must either be from the *supreme* mind, or from some *subordinate* mind, acting under the supreme, but wholly *distinct from and independent* of that which each man calls himself.

(N) "Non cum illis componi prorsus potest ARISTOTELES, qui bina rerum separataque statuunt principia, Deum ne Im-mortality of the Soul.

ing separately, but eternally linked together by the closest union; we think it follows undeniably, that this heat, from which he derived all souls, must be that mind which he called *God*, and which he considered as the actuating soul of the universe.

Upon these principles neither Aristotle nor the Stoics could believe with Plato, that in the order of nature there was first an emanation from the Supreme Mind to animate the universe, and then through this universal soul other emanations to animate mankind. The Stagyrite believed, that the Supreme Mind himself is the soul of the world, and that human souls are immediately derived from him. The genuine Stoics, acknowledging but one substance, of necessity considered both the souls and bodies of men as portions of that substance, which they called *το εν*; though still they affected to make some unintelligible distinction between body and mind. But however the various schools differed as to those points, they were unanimous as to the soul's being a part of the self-existing Substance; and Cicero gives their whole system from Pacuvianus in words which cannot be misunderstood:

> Quicquid est hoc, omnia animat, format, alit, auget, creat,
> Sepelit, recipitque in sese omnia, omniumque idem est Pater:
> Indidemque eadem, quæ oriuntur de integro, atque eodem occidunt.

266 On these principles maintained the necessary existence of the soul;

To these verses he immediately subjoins the following query: "Quid est igitur, cur, cum domus sit omnium una, eaque communis, cumque *animi hominum* SEMPER FUERINT, FUTURIQUE SINT, cur ii, quid ex quoque eveniat, et quid quamque rem significet, perspicere non possint *?" And upon the same principle he elsewhere argues, not merely for the immortality, but for the *eternity* and *necessary existence* of the soul: "Animorum nulla in terris origo inveniri potest: His enim in naturis nihil inest, quod vim memoriæ mentis, cogitationis habeat; quod et præterita teneat, et futura provideat, et complecti possit præsentia; quæ sola divina sunt. Nec invenietur unquam, unde ad hominem venire possint, nisi à Deo. Ita quicquid est illud, quod sentit, quod sapit, quod vult, quod viget, cæleste et divinum est; OB EAMQUE REM ÆTERNUM SIT NECESSE EST †." This was indeed securing the future permanency of the soul in the most effectual manner; for it is obvious, that what had not a beginning can never have an end, but must be of eternal and necessary existence.

* De Divinatione, i. p. 57.

† Frag. de Consolatione.

267 but not in distinct and personal capacity.

But when the ancients attributed a proper eternity to the soul, we must not suppose that they understood it to be eternal in its *distinct* and *personal existence*. They believed that it proceeded or was *discerpted* in *time* from the substance of God, and would *in time* be again *resolved* into that substance. This they explained by a close vessel filled with sea water, which swimming a while upon the ocean, does, on the vessel's breaking, flow in again, and mingle with the common mass. They only differed about the time of this reunion; the greater part holding it to be at death; but the Pythagoreans not till after many transmigrations. The Platonists went between these two opinions; and rejoined pure and unpolluted souls immediately to the Universal Spirit; but those which had contracted much defilement, were sent into a succession of other bodies, to be purged and purified, before they returned to their parent substance *."

* Warburton's Divine Legation.

268 A similar doctrine held by the Bramins.

A doctrine similar to this of Plato has been held from time immemorial by the Bramins in India, whose sacred books teach, "That intellect is a PORTION of the GREAT SOUL of the universe, breathed into all creatures, to animate them for a certain time; that after death it animates other bodies, or returns like a *drop* into that *unbounded ocean* from which it first arose; that the souls of men are distinguished from those of other animals, by being endowed with reason and with a consciousness of right and wrong; and that the soul of him who adheres to right as far as his powers extend, is at death ABSORBED INTO THAT DIVINE ESSENCE, never more to re-animate flesh. On the other hand, the souls of those who do evil, are not at death disengaged from all the elements; but are immediately clothed with a body of fire, air, and *akash* (a kind of celestial element, through which the planets move, and which makes no resistance) in which they are for a time punished in hell. After the season of their grief is over, they reanimate other bodies: and when they arrive through these transmigrations at a state of purity, they are absorbed into God, where all PASSIONS are UTTERLY UNKNOWN, and where CONSCIOUSNESS IS LOST IN BLISS †."

† See *Preliminary Dissertation to Dow's History of Indostan.*

269 This doctrine incompatible with a future state of rewards and punishments, and

Whether the Greeks derived their notions of the divinity and transmigration of souls from the east, or whether both they and the Bramins brought the same doctrines at different periods from Egypt, it is foreign from the purpose of this article to inquire. Certain it is, that the philosophers of Greece and India argued in the very same manner, and upon the very same principles, for the *natural* immortality of the soul; and that the immortality which they taught was wholly incompatible with God's moral government of the world, and with a future state of rewards and punishments. That this is true of the doctrine of the Bramins, is evident from the last-quoted sentence: for if the soul when absorbed into the Divine essence, loses all consciousness of what it did and suffered in the body, it cannot possibly be rewarded for its virtues practised upon earth. That the philosophers of Greece taught the same cessation of consciousness, might be inferred with the utmost certainty, even though we had not Aristotle's express declaration to that purpose: For as they all believed their souls to have existed before they were infused into their bodies, and as each must have been conscious that he remembered nothing of his former state (o), it was impossible to avoid concluding,

Deum et materiam. Arctissime enim utrumque hoc initium conjunxit Stagyrita, atque ipsa naturæ necessitate Deum cohærere cum mole hac corporea putavit." *Cudworth's Intellectual System*, Book i. Chap. iv. Sect. 6. note 3.

(o) This is expressly acknowledged by Cicero, though he held with his Greek masters the eternity of the soul. In cluding, that in the future state of his soul as little would be remembered of the present. Accordingly Aristotle teaches, that "the agent intellect only is immortal and eternal, but the passive corruptible,"—τουτο μονον αθανατον και αιδιον ὁ δε παθητικος νους φθαρτος *. Cudworth thinks this a very doubtful and obscure passage; but Warburton, whose natural acuteness often discovered the sense of ancient authors when it had escaped the sagacity of abler scholars, has completely proved, that by the *agent intellect* is meant the *substance* of the soul, and by the *passive* its *particular perceptions*. It appears therefore that the Stagyrite, from the common principle of the soul's being a part of the Divine substance, draws a conclusion against a future state of rewards and punishments; which though all the philosophers (except Socrates) embraced, yet all were not so forward to avow.

270
Grossly absurd in itself;

That the hypothesis of the soul's being a part of the Divine substance is a gross absurdity, we surely need not spend time in proving. The argument long ago urged against it by St Austin must ere now have occurred to every reader. In the days of that learned father of the church, it was not wholly given up by the philosophers; and in his excellent work of the *City of God*, he thus exposes its *extravagance* and impiety: "Quid infelicius credi potest, quam Dei partem vapulare, cum puer vapulat? Jam vero *partes Dei* fieri *lascivas*, *iniquas*, *impias*, atque omnino *damnabiles*, quis ferre potest nisi qui prorsus insanit?

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yet the only principle from which the soul can be inferred to be essentially immortal.

But though this hypothesis be in the highest degree absurd and wholly untenable, we apprehend it to be the only principle from which the *natural* or *essential* immortality of the soul can possibly be inferred. If the soul had a *beginning* it *may* have an *end;* for nothing can be more evident than that the being which had not existence of itself, cannot of itself have perpetuity of existence. Human works, indeed, continue in being after the power of the workman is withdrawn from them; but between human works and the Divine there is this immense difference, that the former receive from the artist nothing but their form; whereas the latter receive from the Creator both their form and their substance. Forms are nothing but modifications of substance; and as substances depend upon God and not upon man, human works are continued in being by that fiat of the Creator, which made the substances of which they are composed susceptible of different forms, and of such a nature as to retain for a time whatever form may be impressed upon them. Human works therefore are continued in being by a power different from that by which they are finished; but the works of God depend wholly upon that power by which they were originally brought into existence; and were the Creator to withdraw his supporting energy, the whole creation would sink into nothing.

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Baxter's argument for the natural or essential immortality of the soul.

Self-evident as this truth certainly is, some eminent philosophers *seem* to have questioned it. "No substance or being (says Mr Baxter *) can have a natural tendency to annihilation, or to become nothing. That a being which once exists should cease to exist is a real effect, and must be produced by a real cause: But this cause could not be planted in the nature of any substance or *being* to become a tendency of its nature; *for it could not be a free cause*, otherwise it must be a *being* itself, the subject of the *attribute freedom*, and therefore not the property of another *being; nor a necessary cause*, for such a cause is only the effect of something imposing that necessity, and so no cause at all."

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Inconclusive,

That the author's meaning in this argument is good, cannot, we think, be controverted; but he has not expressed himself with his usual accuracy. He seems to confound *causes* with the *absence* of causes, and the *effects* of the *former* with the *consequences* of the *latter*. The visible world was brought into existence by the actual energy of the power of God; and as the visible world had nothing of itself, it can *remain* in existence only by a *continuance* of the *same energy*. This energy therefore is at the present moment as *real a cause* as it was six thousand years ago, or at any period when it may have been first exerted; and the visible world is its *real and permanent effect*. But would the ceasing of this energy be likewise a *cause?* It would certainly be followed with the annihilation of the visible world, just as the withdrawing of the sun-beams would be followed with darkness on the earth. Yet as no one has ever supposed that darkness, a nonentity, is a *positive effect* of the sun or of his beams, but only a mere negative consequence of their absence; so, we think, no one who believes in creation can consider that destruction which would inevitably follow the withdrawing of the energy by which all things are supplied, as the *positive effect* of a contrary energy, or as any thing more than a *negative consequence* of the ceasing of that volition or energy of power by which God at first brought things into existence. For "where the *foundation* of existence lies *wholly* in the power of an infinite Being *producing*, the *ground* of the *continuance* of that existence must be wholly in the same power *conserving;* which, has therefore, with as much truth as frequency, been styled a continued creation (P)."

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and in effect given up by himself.

The force of this reasoning Mr Baxter certainly saw, when he said, that "a tendency to persevere in the same state of nature, and a tendency to change it, are contradictories, and impossible to be planted in the same subject at once: or, not to urge the contradiction, if the last prevailed, the remaining in the same state for any given time would be impossible. We forget the true cause of all these tendencies, *the will of God*, which it is absurd to suppose contrary to itself. The tendency in matter to persevere in the same state of rest or motion, is nothing but *the will of the Creator*, who preserves all things in their existence and manner of existence: nor can we have recourse to any other cause

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* *De Anima*, lib. iii. cap. 6.

* *Inquiry into the Nature of the Human Soul*, vol. i. sect. 3.

In answer to some very foolish assertions concerning the evil of death, he says, "Ita, qui nondum nati sunt, miseri jam sunt, quia non sunt: et nos ipsi, si post mortem miseri futuri sumus, miseri fuimus antequam nati. Ego autem *non commemini*, *antequam sum natus*, *me miserum*. *Tuscul.* lib. i. cap. 6.

(P) See Stillingfleet's *Origines Sacræ*, where this question is treated in a very masterly manner by one of the ablest metaphysicians of the 17th century. See also our article PROVIDENCE.

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cause for the preservation of immaterial substance in its existence. Therefore these tendencies are to be ascribed to the will of God, and it is absurd to suppose them contrary."

275 Analogical evidence of the immortality of the soul, and a moral proof of a future state of rewards and punishments.

All this is unquestionably true. The existence or nonexistence of matter and of created spirits depends wholly upon the will of God; and we cannot suppose him to be willing to-day the reverse of what he willed yesterday, because we know that all his volitions are directed by unerring wisdom. We have likewise the evidence of experience, that nothing is ever suffered to perish but particular systems, which perish only *as systems* by a decomposition of their parts. A being, which like the soul has no parts, can suffer no decomposition; and therefore, if it perish, it must perish by annihilation. But of annihilation there has not hitherto been a single instance; nor can we look for a single instance without supposing the volitions of God to partake of that unsteadiness which is characteristic of man. Corporeal systems, when they have served their purpose, are indeed resolved into their component parts; but the matter of which they were composed so far from being *lost*, becomes the matter of *other systems* in endless succession. Analogy, therefore, leads us to conclude, that when the human body is dissolved, the immaterial principle by which it was animated continues to think and act, either in a state of separation from all body, or in some material vehicle to which it is intimately united, and which goes off with it at death; or else that it is preserved by the Father of spirits, for the purpose of animating a body in some future state. When we consider the different states through which that living and thinking *individual*, which each man calls himself, goes, from the moment that it first animates an embryo in the womb, to the dissolution of the man of fourscore; and when we reflect likewise on the wisdom and *immutability* of God, together with the various dissolutions of corporeal systems, in which we know that a single atom of matter has never been lost; the presumption is certainly strong, that the soul shall subsist after the dissolution of the body. But when we take into the consideration the *moral* attributes of God—his justice and goodness, together with the unequal distribution of happiness and misery in the present world; this presumption from analogy amounts to a *complete moral proof* that there shall be a future state of rewards and punishments (Q) (see MORAL *Philosophy* and RELIGION): and if we estimate the duration of the rewards by the benevolence of Him by whom they are to be conferred, we cannot imagine them shorter than eternity.

CHAP. V. *Of* NECESSITY *and* LIBERTY.

276 Freedom of agency implied in accountableness.

IN the preceding chapter we have adverted to that great *moral proof* for a future state, and the immortality of the soul, arising from the relation in which man, as a being accountable for his conduct, stands to a God of almighty power, infinite wisdom, and perfect justice. But the circumstance of accountableness implies freedom of agency; for it is contrary to all our notions of right and wrong (see MORAL *Philosophy*), that a man should be either rewarded or punished for actions which he was necessitated or compelled to perform.

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277 Every man has power to do what he wills:

Human actions are of three kinds: one, where we act by instinct, without any view to consequences; one, where we act by will, in order to obtain some end; and one, where we act against will. It is the second kind of actions only which confers upon the agent merit or demerit. With respect to the first, he acts blindly (see INSTINCT), without deliberation or choice; and the external act follows from the instinctive impulse, no less necessarily than a stone by its gravity falls to the ground. With respect to the last, he is rather an instrument than an agent; and it is universally allowed, that were a strong man to put a sword into the hand of one who is weaker, and then to force it through the body of a third person, he who held the sword would be as guiltless of the murder as the sword itself. To be entitled to rewards, or liable to punishment, a man must act voluntarily; or in other words, his actions must proceed from that energy of mind which is termed *volition;* and, we believe, it has never been denied, that all men have power to do whatsoever they *will*, both with respect to the operations of their minds and the motions of their bodies, uncontrouled by any foreign principle or cause. "Every man (says Priestley) is at liberty to turn his thoughts to whatever subject he pleases, to consider the reasons for or against any scheme or proposition, and to reflect upon them as long as he shall think proper; as well as to walk wherever he pleases, and to do whatever his hands and other limbs are capable of doing." Without such liberty as this, morality is inconceivable.

278 But different opinions entertained of the freedom of volition.

But though philosophers have in general agreed with respect to the power which a man has to perform such actions as he wills, they have differed widely in opinion respecting the nature of his volitions. That these are the result of motives, has seldom if ever been questioned; but whether that result be necessary so as that the agent has no self-determining power to decide between different motives, has been warmly disputed by men equally candid, impartial, and intelligent. The principal writers on the side of necessity are, Hobbes, Collins, Hume, Leibnitz, Lord Kames, Hartley, Edwards, Priestley, and perhaps Locke. On the other side are Clarke, King, Law, Reid, Butler, Price, Bryant, Wollaston, Horsley, Beattie, and Gregory,

(Q) It was by such arguments that Socrates reasoned himself into the belief of a future state of rewards and punishments. He was singular, as we have already observed, in this belief; and he was as singular in confining himself to the study of morality. "What could be the cause of this belief, but this restraint, of which his belief was a natural consequence? For having confined himself to morals, he had nothing to mislead him; whereas the rest of the philosophers, applying themselves with a kind of fanaticism to *physics* and *metaphysics*, had drawn a number of absurd, though subtle, conclusions, which directly opposed the consequences of those moral arguments."
Warburton s Div. Leg. vol. ii.

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gory, &c. To give a short view of this celebrated question, is all that our limits will permit; and as we do not think ourselves competent to settle the dispute, it were perhaps a thing desirable to give the opposite reasonings in the words of those eminent authors themselves. It must, however, be obvious to the reader, that the style and manner of so many different writers are extremely various, and that to introduce them all into our abstract, would make the whole a mass of confusion. We shall, therefore, select one writer to plead the cause of necessity, supplying his defects from those who, though inferior to him on the whole, may yet have argued more ably on some particular points which the question involves; and to this combined reasoning we shall subjoin such answers as to us appear most conclusive. Hartley, Hume, and Priestley, are perhaps the most profound reasoners on the side of necessity; but there is so much more perspicuity in the arguments of Lord Kames, that we cannot help preferring them, as being on the whole better calculated to give the ordinary reader a fair view of the subject.

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Scheme of necessity, according to Lord Kames.

"Into actions done with a view to an end (says his lordship*), desire and will enter: desire to accomplish the end goes first; the will to act, in order to accomplish the end, is next; and the external act follows of course. It is the will then, that governs every external act done as a mean to accomplish an end; and it is desire to accomplish the end that puts the will in motion; desire, in this view, being commonly termed the *motive* to act. But what is it that raises desire? The answer is ready: It is the prospect of attaining some agreeable end, or of evading one that is disagreeable. And if it be inquired, what makes an object agreeable or disagreeable? the answer is equally ready: It is our nature that makes it so. Certain visible objects are agreeable, certain sounds, and certain smells: other objects of these senses are disagreeable. But there we must stop; for we are far from being so intimately acquainted with our own nature as to assign the causes.

* *Sketches of the History of Man*, Book iii. Sketch 2. part 1. sect. 8.

"With respect to instinctive actions, no person, I presume, thinks that there is any freedom. With respect to voluntary actions, done in order to produce some effect, the necessity is the same, though less apparent at first view. The external action is determined by the will: the will is determined by desire; and desire by what is agreeable or disagreeable. Here is a chain of causes and effects, not one link of which is arbitrary, or under command of the agent: he cannot will but according to his desire; he cannot desire, but according to what is agreeable or disagreeable in the objects perceived: nor do these qualities depend on his inclination or fancy; he has no power to make a beautiful woman ugly, nor to make a rotten carcase smell sweetly.

"Many good men, apprehending danger to morality from holding our actions to be necessary, endeavour to break the chain of causes and effects above mentioned; maintaining, that whatever influence desire or motives may have, it is the agent himself who is the cause of every action; that desire may advise, but cannot command; and, therefore, that a man is still free to act in contradiction to desire and to the strongest motives.

"That a being may exist which in every case acts blindly and arbitrarily, without having any end in view, I can make a shift to conceive: but it is difficult for me even to imagine a thinking and rational being, that has affections and passions, that has a desirable end in view, that can easily accomplish this end; and yet after all can fly off or remain at rest, without any cause, reason, or motive, to sway it. If such a whimsical being can possibly exist, I am certain that man is not that being. There is not, perhaps, a person above the condition of a changeling, but can say *why* he did so and so, what moved him, what he intended. Nor is a single fact stated to make us believe that ever a man acted against his own will or desire, who was not compelled by external force.—On the contrary, constant and universal experience proves, that human actions are governed by certain inflexible laws; and that a man cannot exert his self-motive power but in pursuance of some desire or motive.

"Had a motive always the same influence, actions proceeding from it would appear no less necessary than the actions of matter. The various degrees of influence that motives have on different men at the same time, and on the same man at different times, occasion a doubt, by suggesting a notion of chance. Some motives, however, have such influence as to leave no doubt: a timid female has a physical power to throw herself into the mouth of a lion roaring for food; but she is withheld by terror no less effectually than by cords: if she should rush upon a lion, would not every one conclude that she was frantic? A man, though in a deep sleep, retains a physical power to act, but he cannot exert it. A man, though desperately in love, retains a physical power to refuse the hand of his mistress; but he cannot exert that power in contradiction to his own ardent desire, more than if he were fast asleep. Now, if a strong motive have a necessary influence, there is no reason for doubting, but that a weak motive must also have its influence, the same in kind, though not in degree. Some actions indeed are strangely irregular; but let the wildest actions be scrutinized, there will always be discovered some motive or desire, which, however, whimsical or capricious, was what influenced the person to act. Of two contending motives, is it not natural to expect that the stronger will prevail, however little its excess may be? If there be any doubt, it must arise from a supposition, that a weak motive may be resisted arbitrarily. Where then are we to fix the boundary between a weak and a strong motive? If a weak motive can be resisted, why not one a little stronger, and why not the strongest? Between two motives opposing each other, however nearly balanced, a man has not an arbitrary choice, but must yield to the stronger. The mind, indeed, fluctuates for some time, and finds itself in a measure loose: at last, however, it is determined by the more powerful motive, as a balance is by the greater weight after many vibrations.

"Such, then, are the laws that govern our voluntary actions. A man is absolutely free to act according to his own will; greater freedom than which is not conceivable. At the same time, as man is made accountable for his conduct to his Maker, to his fellow

low creatures, and to himself, he is not left to act arbitrarily; for at that rate he would be altogether unaccountable: his will is regulated by desire; and desire by what pleases or displeases him.—Thus, with regard to human conduct, there is a chain of laws established by nature; no one link of which is left arbitrary. By that wise system, man is made accountable; by it he is made a fit subject for divine and human government: by it persons of sagacity foresee the conduct of others; and by it the prescience of the Deity with respect to human actions is clearly established."

Of the doctrine of necessity, a more perspicuous or plausible view than this is not to be found in any work with which we are acquainted. It is indeed defective, perhaps, as his lordship only *hints* at the *nature* of that relation which subsists between motive and action; but from his comparing the fluctuations of the mind between two contending motives, to the vibrations of a balance with different weights in the opposite scales, there is no room to doubt but that he agreed exactly in opinion with Mr Hume and Dr Priestley. Now, both these writers hold, that the relation of motives to volition and action, is the very same with that which subsists between cause and effect in physics, as far as they are both known to us.

280 Hume, Inquiry concerning Human Understanding, sect. 8.

"It is universally allowed (says Mr Hume *), that matter, in all its operations, is actuated by a necessary force; and that every natural effect is so precisely determined by the energy of its cause, that no other effect, in such particular circumstances, could possibly have resulted from it. The degree and direction of every motion is, by the laws of nature, prescribed with such exactness, that a living creature may as soon arise from the shock of two bodies, as motion in any other degree or direction than what is actually produced by it. Would we, therefore, form a just and precise idea of *necessity*, we must consider whence that idea arises, when we apply it to the operation of bodies. But our idea of this kind of necessity and causation arises entirely from the uniformity observable in the operations of nature, where similar objects are constantly conjoined together, and the mind is determined by custom to infer the one from the appearance of the other. These two circumstances form the whole of that necessity which we ascribe to matter. Beyond the *constant conjunction* of similar objects, and the consequent *inference* from one to the other, we have no notion of any necessity or connexion." He then gives a pretty long detail to prove a great uniformity among the actions of men in all nations and ages; and concludes that part of his argument with affirming, "not only that the conjunction between motives and voluntary actions is as regular and uniform as that between the cause and effect in any part of nature; but also, that this regular conjunction has been universally acknowledged among mankind, and has never been the subject of dispute either in philosophy or common life." He afterwards observes, "That men begin at the wrong end of this question concerning liberty and necessity, when they enter upon it by examining the faculties of the soul, the influence of the understanding, and the operations of the will. Let them first discuss a more simple question, namely, the operations of body, and of brute unintelligent matter, and try whether they can there form any idea of causation and necessity, except that of a constant conjunction of objects, and subsequent inference of the mind from one to another. If these circumstances form in reality the whole of that necessity which we conceive in matter, and if these circumstances be also universally acknowledged to take place in the operations of the mind, the dispute is at an end; at least must be owned to be thenceforth merely verbal. When we consider how aptly *natural* and *moral* evidence link together, and form only one chain of argument, we shall make no scruple to allow that they are of the same nature, and derived from the same principles.—Between a connected chain of natural causes and voluntary actions, the mind feels no difference in passing from one link to another; nor is less certain of a future event which depends upon motives and volitions, than if it were connected with the objects present to the memory and senses by a train of causes, cemented together by what we are pleased to call a *physical* necessity. The same experienced union has the same effect on the mind, whether the united objects be motives, volition and action, or figure and motion. We may change the names of things, but their nature and their operation on the understanding never change."

Dr Priestley, in words a little different, teaches the very same doctrine which was taught by Mr Hume.— 281 Dr Priestley.
"In every determination of the mind (says he *), or in cases where volition and choice are concerned, all the previous circumstances to be considered are the *state of mind* (including *every thing belonging to the will itself*), and the *views of things* presented to it; the latter of which is generally called the *motive*, though under this term some writers comprehend them both. To distinguish the *manner* in which events depending upon *will* and *choice* are produced, from those in which no volition is concerned, the former are said to be produced *voluntarily*, and the latter *mechanically*. But the same general maxims apply to them both. We may not be able to determine *à priori* how a man will act in any particular case; but it is because we are not particularly acquainted with his *disposition of mind, precise situation*, and *views of things*. But neither can we tell in which way the wind will blow to-morrow, though the *air* is certainly subject to no other than necessary laws of motion.

* *The Doctrine of Philosophical Necessity illustrated.*

"It is universally acknowledged, that there can be no effect without an adequate cause. This is even the foundation on which the only proper argument for the being of a God rests. And the necessarian asserts, that if, in any given state of mind, with respect both to *disposition* and *motives*, two different determinations or volitions be possible, it can be so on no other principle, than that one of them shall come under the description of an *effect without a cause*; just as the beam of a balance might incline either way, though loaded with equal weights. It is acknowledged, that the mechanism of the balance is of one kind, and that of the mind of another; and, therefore, it may be convenient to denominate them by different words; as, for instance, that of the balance may be termed a *physical*, and that of the mind a *moral* mechanism. But still, if there be a *real mechanism* in both cases, so that there can be only one result

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result from the same previous circumstances, there will be a *real necessity*, enforcing an absolute certainty in the event. For it must be understood, that all that is ever meant by *necessity in a cause*, is that which produces *certainty in the effect*."

Such is the nature of human volitions, according to every necessarian of eminence who has written on the subject since the days of Hobbes: and if this theory be just, if there be a constant and inseparable conjunction of motives and actions similar to that of cause and effect in physics, it is obvious, that in volition the mind is as inert as body is in motion.

282 View of human liberty.

This consequence is indeed avowed and insisted upon by Hume, Priestley, and their adherents; whilst the advocates for human liberty, on the other hand, contend for an absolute exemption of the will from all internal *necessity*, arising from its own frame and constitution, the impulse of superior beings, or the operations of objects, reasons, or motives, &c. By this they do not mean, that between motives and volitions there is no relations whatever, or that a man can ever choose evil as evil, or refuse good as good. Such an assertion would be contrary to consciousness and universal experience. But what they endeavour to prove is, that the conjunction of motive and volition is not inseparable, like that of cause and effect in physics; that a man may in most cases choose according to any one of two or more motives presented to his view; that by choosing any thing, he may make it in some measure agreeable by his own act, or, to speak more properly, may bend his desire to it; that in volition, the mind is not enert; and that, therefore, we are under no *necessity* to act in a particular manner in any given case whatever.

That the conjunction of motive and action is not constant like that of cause and effect in physics, and that by consequence the mind in forming volitions is not inert, has been evinced by Dr Gregory with the force and precision of mathematical demonstration.—Former writers on the side of liberty had often observed, that upon the supposition of the *inertia* of mind, a man, with equal and opposite motives presented at once to his view, would, during their continuance, remain perfectly at rest, like a balance equally loaded in both scales. The observation is admitted to be just by all the advocates for necessity; but they contrive to evade its consequences, by denying that in any given case a man can be at once assailed by two equal and opposite motives. Thus, when it is said that a porter, standing with his face due north, must remain in that position at perfect rest, as long as equal motives shall at once be offered to him for travelling eastward and westward, the necessarians admit the force of the argument; but when it is added that a guinea, offered for every mile that he should travel in each of these opposite directions, ought therefore to fix him at rest till one of the offers be withdrawn, they deny that the desire of gaining the guineas is the *whole* of the motives which operate upon his mind. He may have, say they, some secret reason which we cannot discern for preferring the one direction to the other; and that reason, added to the guinea, will make him go eastward or westward, just as an ounce thrown into either scale of a balance poised by equal weights will make that scale preponderate. Though we think that this solution of the difficulty can satisfy no man who is not already biassed to the necessarian system; and though, even were it to be admitted, it seems to militate against the constant conjunction of motives and actions, unless it can be proved that the porter must travel the road which he has been necessitated to choose with reluctance and a heavy heart; yet as it may admit of endless quibbling upon ambiguous words, the philosophical world is much indebted to Dr Gregory † for an argument which, in our opinion can neither be overturned nor evaded, and which demonstrates that the conjunction of motive and action cannot be constant and inseparable, like that of cause and effect in physics.

† *Essay on the Relation between Motive and Action.*

283 Demonstration that the conjunction of motive and action is not constant.

His reasoning is to this purpose: Suppose a porter to be offered a guinea for every mile that he shall travel directly eastward. If there be no physical cause or moral motive to keep him at rest, or to induce him to move in another direction, there cannot be a doubt, upon either hypothesis, but he will gladly embrace the proposal, and travel in the direction pointed out to him, till he shall have gained as much money as to satisfy his most avaricious desires. The same thing would have happened, if a guinea had been offered for every mile that he should travel due south. In these two cases taken separately, the relation between the man's motions and his actions would be strikingly analogous to that between a single impulse and motion in physics. Let us now suppose the two offers to be made at the same instant, and the man to be assured that if he travel eastward he can have no part of the reward promised for his travelling to the south, and that if he travel southward he can have no part of the reward promised for his travelling to the east. What is he to do in this case? If his mind be inert in volition, and if the two motives operate upon him with the same necessity that causes operate in physics, it is obvious that the man could travel neither towards the east nor towards the south, but in a diagonal direction from north-west to south-east; and this he must do *willingly*, although perfectly satisfied that he could gain nothing by his journey. As this inference is contrary to fact and universal experience, the doctor very justly concludes that the premises, from which it is deduced by mathematical reasoning, must be false and absurd; or, in other words, that the relation between motive and action cannot be that of constant conjunction, like the relation between cause and effect in physics.

He uses many arguments of the same kind, and equally convincing, to prove the absurdity of supposing the inertness of mind, and only an occasional conjunction of motives and actions; but we forbear to quote them, both because we wish his book to be read, and because we think the single argument which we have borrowed from him sufficient to demolish the theory of Priestley and Hume, which rests wholly upon the hypothesis of the *constant* conjunction of motive and action.

But is it then not really true, that the external action is determined by the will, the will by desire, and desire by what is agreeable or disagreeable? That the external action is universally determined by the will, is certainly true; but that the will is necessitated and universally determined by the desire is as certainly false. If Potiphar's

Potiphar's wife was handsome, and made her proposals to Joseph with any degree of female address; and if his constitution was like that of other young men; there cannot be a doubt but that he felt a *desire* to do what she requested of him: yet we know that he *willed* to do otherwise, and in direct opposition to his *desire* fled from the room. Perhaps it may be said, that his volition to flee was the effect of a contrary and stronger *desire* not to sin against God; but this is confounding the reader, by calling two energies of mind, between which there is little or no similarity, by the same name. He perceived, or knew, that to comply with his mistress's request would be to sin against God; he knew that he ought not to sin against God, and therefore he chose or determined himself not to do it. We can easily conceive how the presence, attitudes, and address, of the lady might be agreeable to him, and excite desire. There may very possibly be more than one of our readers, who, during the course of their lives, have experienced something of the same kind: but could abstract truth be in the same way agreeable, so as to excite in his mind a *desire* of virtue sufficient to annihilate or banish the *desire* of the woman? As well may it be said that one sensation can annihilate another, that the beautiful colours of the rainbow can remove the sensation of stench from the mind of him who is plunged into the midst of a dunghill, or that the smell of a rose can make a man insensible to the pain of a stroke inflicted by a bludgeon. Sensitive desire, and the perception of duty, are things so totally different, that to consider them as operating against each other, like different weights in the opposite scales of a balance, is as absurd as to suppose that sound can operate against colour, or colour against smell. A man may prefer sound to colour, or colour to smell, and act accordingly; but the determination must be wholly his own, unless these two sensations be themselves either agents or physical causes of the *same kind*, like the weights in the opposite scales of the balance.

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The advocates for liberty do not pretend, that in matters of importance a man ever acts without some motive or reason for his conduct. All that they insist upon is, that between two or more motives of different kinds he has a liberty of choice, and that he does not always determine himself by that which he knows to be the greatest. Without such freedom, they think men might be often brought into situations where they could not act at all, and where inaction would at the same time be in the highest degree absurd. Thus, were two bags of gold containing each a thousand or ten thousand guineas, to be placed on the same table, before a man whose family is perishing for want, and were the man to be told that he might take either of them, but not both, is it conceivable that he would be held in perpetual suspense between the two? No; he would instantly and with alacrity take up one of them, without feeling the least regret for the want of the other. This action would, indeed, be the consequence of a very powerful motive, the desire to obtain honestly that wealth of which he and his family stood so much in need. That motive, however, being general, would draw him equally to both bags; and it remains with the necessarians to say by what else than a self-determining power he could take either the one or the other. When it is affirmed, that such self-determination would be an effect without a cause, the advocates for liberty cannot help thinking that their antagonists are guilty of advancing as an argument a *petitio principii*; for the affirmation is true, only if the mind in volition be inert, and the *inertia* of the mind is the sole question at issue. If the mind be not inert, it is plain, that in consequence of a man's self-determination, no effect would be produced without a sufficient cause. At any rate, motives cannot be causes. In the proper sense of the word, a cause is that which produces an effect; but the production of an effect requires active power; and power being a quality, must be the quality of some being by whom it may be exerted. Power may be dormant, and therefore power without will produces no effect. Are motives, then, real beings endowed with power and will? No; they are only views of things or mental conceptions, which in the strictest sense of the word are passive; and between two motives the mind determines itself, without receiving an impulse from either.

Nor is it only between motives of equal force that men have the power of determining themselves. Whoever believes in a future state of rewards and punishments, and yet acts in a manner which he knows to be offensive to Him who is to be the future and final judge, unquestionably prefers to the strongest of all motives, another which even to himself appears to have comparatively but very little strength. Whether there be men who occasionally act in this manner, is a question which can be decided only by an appeal to every one's consciousness. That there are, we can have no doubt; for we never met with a single individual, not biassed by system, who was not ready to acknowledge, that during the course of his life he had done many things, which at the time of action he clearly perceived to be contrary to his true interest. Without a self-determining power in the mind, this could never be the case. Did motives operate with the necessity of physical causes, it is obvious that in every possible situation the strongest must constantly prevail; and that he who in certain circumstances had in time past done any particular thing, would on a return of the same circumstances do the very same thing in every time future. Dr Priestley, indeed, wishes to persuade his readers that this is actually the case. "In every determination of the mind (says he), or in cases where volition and choice are concerned, all the previous circumstances to be considered are the *state of mind* (including) *every thing belonging to the will itself*), and the various views of things presented to it;" and he affirms, that "whenever the same precise circumstances occur twice, the very same determination or choice will certainly be made the second time that was made the first." This is an assertion of which no man can controvert the truth; for it is an identical proposition. If in the circumstances previous to the determination of the mind, *every thing* belonging to the *will itself* must be included, it is self-evident that he who in any given circumstances has acted a particular part, will on a return of these circumstances act the same part a second time; for this is only saying, that he who on two different occasions shall exert volitions of the same tendency, will not on these occasions exert volitions of which the tendencies are different. But the question

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to be decided is, Whether a man, in the same general state of mind, possessed of the same degree of health, and conscious of the same appetites, must, in external circumstances perfectly alike, necessarily exert at all times the same volitions. That the human mind is under no such necessity, we think every man's consciousness and experience may abundantly satisfy him; for there are, perhaps, but very few who have not at one time resisted temptations, to which at another they have chosen to yield.

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If they did, folly as well as merit and demerit would be banished from the world.

That there is a relation between motives and actions, must be confessed; but that relation is neither *necessity*, nor constant conjunction. If it were, all actions would be perfectly rational; and folly, as well as merit and demerit, would be banished from the conduct of men. What is the particular nature of that relation which subsists between the voluntary actions of men, and the motives from which they proceed, can be known to every individual only by an attentive and unbiassed reflection on the operations of his own mind. Without this reflection, no man can be made to understand it by the reasonings of philosophers, and with it no man can need the aid of those reasonings. That a self-determining power, such as that for which we plead, contributes to the sum of human happiness, has been shown by Archbishop King and his ingenious translator; who have proved, with the force of demonstration, that the mind can take pleasure in the object of its choice, though that object be in itself neither agreeable nor disagreeable to our natural appetites; and that if it could not, it would be in vain in such a world as ours to hope for any portion of felicity. Into that detail our limits will not permit us to enter: but to the reader who wishes for further information, we beg leave to recommend the last edition of King's Origin of Evil, by Dr Law late bishop of Carlisle; without, however, vouching for the truth of all the opinions advanced by either of those learned writers.

Before we conclude this chapter, it may be proper to observe, that it is only in volition that we are conscious of any original active power in ourselves, and that without such consciousness we could never have acquired the *notion* of active power. In our desires and appetites, we neither are active nor suppose ourselves active. Lord Kames, and most necessarians, confound desire with volition; but that they are perfectly distinct is plain from this circumstance, that we daily *desire* many things which we know to be wholly *out* of our own power *, whereas no man ever *willed* what he did not believe to be *in* his own power. We all *desire* or wish that our children may be virtuous, wise, and happy; and though we are conscious that it is not in our power to make them so, we cannot banish the desire from our breasts. But madmen only have ever *willed* virtue, wisdom, and happiness, to any person; and if there was ever a man so extravagantly mad as to exert such a volition as this, he has at the time fancied himself a divinity, and therefore believed that the object of his volition depended upon himself. When the astronomer, whose character is so admirably drawn by our great master of moral wisdom †, fancied himself the regulator of the weather and the distributor of the seasons, he might *will* either *rain* or *sunshine* as he thought proper, because he considered the object of his volition as depending upon a power imparted to him from heaven; but though he might *desire* he could not *will*, the rising or the falling of *winds*, for these he confessed were not subjected to his authority. In a word, without freedom in volition power is inconceivable; and therefore it is as certain that we are free agents, as that we have any notion of active powers.

* *Reid's Essays on the Active Powers of Man.*

† *Rasselas Prince of Abyssinia.*

Chap. VI. *Of the* Being *and* Attributes *of* God.

Of the Being and Attributes of God.

It has been already observed, that as of bodies there are various kinds, endowed with various properties; so the probability is, that of minds endowed with different powers, or different degrees of power, the variety may be as great, or perhaps greater. The existence and powers of our own minds are made known to us by consciousness and reflection; and from our dependent state, and the mutability of the objects around us, we are necessarily led to infer the existence of another mind, which is independent, unchangeable, eternal, and the cause of all things which have a beginning of existence. Between that mind and our own, we can hardly avoid believing that there are many orders of "thrones, dominations, princedoms, virtues, powers;" but as we have no intuitive knowledge of such intermediate beings, and cannot from any thing which we perceive discern the *necessity* of their existence, they are not properly the object of science. The existence however, and many of the attributes, of One First Cause, are capable of the strictest demonstration; "for the invisible things of him from the creation of the world are clearly seen, being understood by the things which are made."

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The existence of God capable of demonstration.

Of this great truth, the most important by far which can occupy the mind of man, many demonstrations have been given both by divines and by philosophers. We shall lay before our readers such a one as to us appears perfectly conclusive, being founded on the intuitive knowledge which we have of our own existence, and therefore independent of all theories about the nature and reality of the material world.

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Some one independent Being has existed from eternity.

Every man, whether he adopt the common theory or that of Berkeley respecting matter, is conscious that he *himself* exists, and must therefore grant that *something now* exists. But, if any thing exists *now* *, then must something have *always* existed; otherwise that thing which *now* exists, must either have been created by *nothing*, i. e. have been *caused by no cause*, or else it must have *created itself*, acting before it existed. Both these suppositions are so palpably absurd, that no atheist has avowed them, either among the ancients or the moderns. We must therefore admit, either that there is some one *independent* being, which now exists, and always has existed; or that the things which we know to exist at present (every man's *self* for instance), were produced by *something* which had its *existence* from *something else*, which also depended upon *some other cause*, and so on in an *infinite series of caused* or *successive beings*. But this last supposition, though it has been often made, is as grossly absurd as either of the two former. For of this infinite series, either *some one* part has *not* been successive to any other, or

* See Notes to King's Origin of Evil.

the Be- and At- butes of God.

or else *all* the several parts of it have been successive. If some one part of it was *not successive*, then it had a *first part*; which destroys the supposition of its infinity (R). If *all* the several parts of it have been successive, then have they all once been *future*; but if they have *all* been future, a time may be conceived when none of them had existence: and if so, then it follows, either that all the *parts*, and consequently the *whole* of this infinite series, must have arisen from *nothing*, which is absurd; or else that there must be something in the *whole* besides what is contained in *all the parts*, which is also absurd.

As the possibility or impossibility of an infinite series of dependent beings is the main question at issue between the atheists and us, we shall state the preceding reasoning in a manner somewhat different. For this purpose, let us suppose some one to affirm, that the course of generation has had no beginning, and consequently that the number of successive births has been infinite. We would ask such a person, Whether before the birth of Abraham, for example *, there had past an infinite series of generations or not? If not, the course of generation must have had a beginning, which is the conclusion for which we contend. But if the series past was infinite, then at the birth of Joseph the great-grandson of Abraham, it is evident, that more generations were past, and that the number then was greater than that which was supposed to be infinite; so that upon this supposition we have a number that is both infinite and not infinite, which is a manifest contradiction. Should it be said that the number of generations was infinite, as well at the birth of Abraham as at the birth of Joseph; it will then follow, that one infinite may be greater than another of the very same kind; and consequently that an infinite may be bounded, i. e. be finite. But should it be alleged, that the number of births at Abraham's was finite, and became infinite when it reached to Joseph's, it will then follow, that one finite number added to another may make an infinite number, which is directly contrary to every possible notion of infinity. We might argue in the same manner against an infinite series of every kind, the very supposition of which involves the most palpable contradictions. See Chap. *Of* INFINITY *and* ETERNITY.

* See an Essay towards an ...iction of Attributes of God, by ...h Ward Printed Oxford, 55.

288 ...ose duration is not commensurate with succession, and

From the impossibility of an infinite series it necessarily follows, that there exists, and must have existed from eternity, some one independent being, whose duration cannot be commensurate with succession, and to whom the relation of time is not applicable. Here will some atheists presently imagine, that by the same mode of reasoning they may disprove the existence of God: for do not they who thus destroy the eternity of the world, destroy at the same time the eternity of the Creator? If time itself be not eternal, how can the Deity or any thing else be so?

In urging these questions, it must be taken for granted that time is essential to all existence, and that God cannot be eternal otherwise than by a successive flux of infinite time. But it has been already shown (N° 224.), that successive duration is not essential to existence; that we can even *conceive* existence without succession; and it may here be added, that if we suppose a perfect being alone in nature, we shall find it impossible to imagine any *succession of ideas*, any *flux of moments*, or any *alteration* or *increase* whatever in his knowledge and essence. Such duration as we are acquainted with can have no relation to an immutable Being, while supposed to exist alone; but as soon as he determined to exercise his several attributes in the production of something distinct from himself, then, and not till then, have we reason to think that *time*, *succession*, and *increase*, began. These atheistical questions, therefore, instead of containing an objection to the existence of a Deity, afford a plain demonstration of it: for since it is not more evident that something now exists than that something must have existed from eternity; and since it has been shown, that neither the world in its present state, nor time, nor any thing capable of change or succession, can possibly be eternal; it follows, that there must necessarily be some Being who, in the order of nature, is before time, and who, in the stability and immutable perfection of his own intelligence, comprehends at once his *yesterday*, *to-day*, and *for ever*. "The atheists (says the excellent Cudworth *) can here only smile, or make wry faces, and show their little wit in quibbling upon *nunc-stans*, or a *standing now of eternity*; as if that *standing eternity* of the *Deity* (which with so much reason hath been contended for by the ancient *genuine theists*) were nothing but a *pitiful small moment of time standing still*, and as if the duration of all beings whatsoever must needs be like our own: whereas the duration of every thing must of necessity be agreeable to its nature; and therefore, as that whose *imperfect nature* is ever *flowing* like a river, and consists in *continual motion* and *changes* one after another, must needs have accordingly a *successive* and *flowing duration* sliding perpetually from *present* into *past*, and always hasting on towards the *future*, expecting something of itself which is not yet in being; so must that whose perfect nature is *essentially immutable* have *permanent and unchanging duration*, never losing any thing of itself once present, nor yet running forward to meet something of itself which is not yet in being."

* *Intellectual System*, book i. chap. 5.

289 who is self-existent, and

From the eternity of the Supreme Being we necessarily infer his independence or self-existence; for that which never had a *beginning* of existence cannot possibly have any cause of that existence, or in any manner depend upon any other being, but must exist of itself, or be *self-existent*.

290 cannot cease to be.

Eternity *ad partem post*, or *necessary existence*, or the impossibility of ever ceasing to be, follows from independence: For to the nature of that which exists without any cause, existence must be essential. But a being whose eixstence is of itself and essential to its nature, cannot be *indifferent* to existence or nonexistence, but must exist *necessarily*. And here it may be proper to observe, that the word *necessity*, when applied to existence, may be taken in two acceptations very different from each other †; either as it arises from the relation which the existence of that being, of which it is affirmed, has to the existence of *other things*; or from the relation which the *actual* existence of that thing has to the *manner* of its *own* existence.

† *Notes to King on Evil*, and *Law's Inquiry into the Ideas of Space*, &c.

In

(R) Των απειρων ουκ εστι ουδεν πρωτον, *Arist. Phys.* lib. viii. cap. 5. sect. 4.

Of the Being and Attributes of God.

In the former sense, when necessity of existence has relation to the existence of other things, it denotes that the supposition of the *non*-existence of that thing of which necessity is affirmed, implies the non-existence of things which we *know to exist*. Thus, some inde-

291 What is meant by necessary existence.

pendent being does *necessarily exist;* because, to suppose *no independent* being, implies that there are *no dependent beings;* the contrary of which we know to be true.

In the second sense, when the necessity of existence arises from the relation which the actual existence of any thing has to the *manner* of its own existence, necessity means, that the thing, of which it is affirmed, exists after such a manner as that it never could in *time past* have *been nonexistent*, or can in *time future cease to be*. Thus, *every independent being*, as it exists without a cause, *is necessarily* existing; because existence is *essential* to such a being; so that it never could *begin* to exist, and never can *cease to be:* For to suppose a being to begin to exist, or to lose its existence, is to suppose a *change* from nonentity to entity, or *vice versa;* and to suppose such a change is to suppose a cause upon which that being depends. Every being, therefore, which is independent, i. e. which had no cause of its existence, must exist *necessarily*, and cannot possibly have begun to exist in time past, or cease to be in time future.

292 Only one necessarily existent being in the former sense; and

These two kinds of necessity as applied to existence, though they have been often confounded, are in themselves perfectly distinct: For though a being cannot be necessarily existent in the *former* sense without being so in the latter also; yet may it be necessarily existent in the latter sense without being so in the former. For any thing that we know to the contrary, there may be two or more beings existing *necessarily* in the latter sense of the word *necessity*, i. e. with regard to *independence* and the *manner* of their own existence: but in the former sense of the word, i. e. in relation to *this system*, there can be but *one necessarily* existent being; for it is obvious that no more are necessary to account for the production of the *dependent* beings which we know to exist. To suppose the non-existence of all *independent* beings, implies the non-existence of all dependent beings, ourselves, and every thing else; but to suppose the non-existence of all independent beings except *one*, involves in the supposition no such absurdity.

293 though there might be more than one in the latter, they would be no gods to us.

Thus the phenomena of nature lead us, by the strictest reasoning, to one first cause, which is sufficient for their production; and therefore none but *one* first cause can in this sense of the word be *necessary:* And though several more *independent* beings might possibly exist, yet they would be no gods to us: they would have no relation to us demonstrable by reason, nor we any thing to do with them. For if the supposition of their existence were not requisite to the production of this system, which it obviously would not be, we could *perceive* no necessity for it at all; we could never discover it by our own faculties, and therefore it could be nothing to us. And though two or three such beings should exist, and act in the formation and government of their *respective* systems, or *agree in one;* yet till their existence and operations were made known to us, and a natural relation discovered, nothing would be due from us to them. They would have no *religious* or *moral* relations to us; and we should have no reason to call more than one of them *our* creator, preserver and governor, which is the proper sense of the word *God*.

To show in this manner that there is only *one* eternal self-existent Being which bears the relation of *God to us*, seems to be going as far as is necessary, or as

294 Impossible to demonstrate that there can be but one self-existent Being

natural light will lead us. Those who endeavour to *demonstrate* that there *cannot possibly* be *more than one* self-existent Being, either reason in a circle, or proceed upon principles which their antagonists cannot be compelled to grant. When they deduce the Divine unity from independence or omnipotence, they evidently presuppose it in their definition of these attributes: and when they infer it from the nature of space and duration, which they consider as modes of the self-existent Being, they take it for granted, that space and duration have a real existence, independent of us and our thoughts; and that the one is infinite and the other eternal, contrary to what has been already proved, we think, with the force of demonstration. The celebrated Dr Clarke made much use of space and duration in his attempt to demonstrate that there can be but one self-existent Being; but he argues for the same thing from the nature of necessity as applied to existence.

295 Dr Clarke's first demonstration of the unity

"Necessity (says he *), absolute in itself, is *simple* and *uniform* and *universal*, without any possible *difference*, *difformity*, or *variety*, whatsoever: and all *variety* or *difference* of *existence* must needs arise from some *external* cause, and be *dependent upon it*, and *proportionable* to the efficiency of that *cause*, whatsoever it be. *Absolute necessity*, in which there can be *no variation* in *any kind* or *degree*, cannot be the *ground* of existence of a *number* of beings, however *similar* and *agreeing:* because, without any *other difference*, even *number* is itself a manifest *difformity* or *inequality* (if I may so speak) of *efficiency* or *causality*."

* *Demonstration of the Being and Attributes of God*, Prop. 7.

296 examined and shown to be inconclusive

Such is this great man's first argument from necessity, to prove that there cannot be more than one self-existent Being. But what is this *necessity* which proves so much? It is the ground of existence (he says) of that which exists of itself; and if so, it must, in the order of nature, and in our conceptions, be antecedent to that being of whose existence it is the ground. Concerning such *a* principle, there are but three suppositions which can possibly be made; and all of them may be shown to be absurd and contradictory. We may suppose either the *substance* itself, some *property* of that substance, or something *extrinsic* to both, to be this *antecedent ground* of existence prior in the order of nature to *the first cause*.

One would think, from the turn of the argument which here represents this antecedent necessity as *efficient* and *causal*, that it were considered as something *extrinsic* to the first cause †. Indeed if the words have any meaning in them at all, or any *force* of argument, they must be so understood, just as we understand them of any external cause producing its effect. But as an *extrinsic* principle is absurd in itself, and is besides rejected by Dr Clarke, who says expressly, that "of the thing which derives not its being from any other thing, this *necessity* or ground of existence must be *in* the thing itself," we need not say a word more of the last of these suppositions.

† *Dissertation on the Argument à priori*, added to *Law's Inquiry into the Ideas of Space, Time, Immensity*, &c.

Let

Of the Being and Attributes of God.

Let us then consider the first; let us take the *substance* itself, and try whether *it* can be conceived as *prior* or *antecedent* to itself in our conceptions or in the order of nature. Surely we need not observe that nothing can be more absurd or contradictory than such a supposition. Dr Clarke himself repeatedly affirms, and it would be strange indeed if he did not affirm, that no *being*, no *thing* whatever, can be conceived as in any respect prior to the first cause.

The only remaining supposition is, that some *attribute* or *property* of the self-existent Being may be conceived as in the order of nature *antecedent* to that being. But this, if possible, is more absurd than either of the two preceding suppositions. An *attribute* is *attributed* to its *subject* as its ground or support, and *not* the *subject* to its *attribute*. A *property*, in the very notion of it, is *proper* to the substance to which it belongs, and *subsequent* to it both in our conceptions and in the order of nature. An *antecedent* attribute, or *antecedent* property, is a solecism as great, and a contradiction as flat, as an *antecedent subsequent* or *subsequent antecedent*, understood in the same sense and in the same syllogism. Every property or attribute, as such, presupposes its subject; and cannot otherwise be understood. This is a truth so obvious and so forcible, that it sometimes extorts the assent even of those who upon other occasions labour to obscure it. It is confessed by Dr Clarke *, that "the scholastic way of proving the *existence* of the self-existent Being from the absolute perfection of his nature, is ὑστερον προτερον. For all or any perfections (says he) presuppose existence; which is a *petitio principii*." If therefore properties, modes, or attributes in God, be considered as perfections (and it is impossible to consider them as any thing else), then, by this confession of the great author himself, they must all or any of them *presuppose* existence. It is indeed immediately added in the same place, "that bare necessity of existence does not presuppose, but infer existence;" which is true only if such necessity be supposed to be a principle *extrinsic*, the absurdity of which has been already shown, and is indeed universally confessed. If it be a *mode* or a *property*, it must *presuppose* the existence of its subject, as certainly and as evidently as it is a *mode* or a *property*. It might perhaps *à posteriori* infer the existence of its subject, as effects may infer a cause; but that it should infer in the other way *à priori* is altogether as impossible as that a *triangle* should be a *square*, or a *globe* a *parallelogram*.

* *Answer to the Sixth Letter.*

297 Second demonstration of the same author.

Doubtful, as it would seem, of the force of his first argument, which even those who pretend to be convinced by it acknowledge to be obscure, the doctor gives a second, which we must confess appears to us to be still more obscure, and if possible less conclusive. "To suppose two or more *distinct beings* existing *of themselves* necessarily and *independent* of each other, implies (he says) this *contradiction*, that *each* of them being independent from the other, they may either of them be supposed to exist *alone*; so that it will be no contradiction to suppose the other not to exist; and consequently *neither of them* will be necessarily existing. Whatsoever therefore exists necessarily is the one simple essence of the self-existent Being; and whatsoever differs from that is not necessarily existing, because in absolute necessity there can be no *difference* or *diversity* of existence.

"Necessity is used here in two different senses *, both as *absolute* and *relative*. In the former, neither of the two beings can exist without the other, i. e. without our supposing the other to exist also, since that is equally necessary. In the latter, either of them may exist alone, i. e. as without the help of the other, or without the supposition of the other as requisite to its own existence. The consequence, therefore, that either of them may exist alone, and so neither of them is necessary, is a mere *equivocation* on *necessity*, using it both in an absolute and relative sense at the same time." But as this is a question of the highest importance, and as the author was a man of great worth, we shall consider his argument upon the supposition that the word *necessity* has from the beginning to the end of it the same invariable meaning.

* *Law's Inquiry into the Ideas of Space*, &c. chap. 6.

298 examined, and shown to be equally inconclusive.

It has been already observed, that there are only two senses in which that word can be applied to the existence of any being; and whether it be here used in the one or the other of these senses, the reasoning, if resolved into a syllogism, will appear to be inconclusive. If the word be taken in that sense of necessity which arises from the relation that dependent beings which we know to exist bear to some one independent Being, the argument will stand thus:

> From a known effect no more causes can be *necessarily* inferred than what are sufficient to account for that effect; but
>
> *One* self-existent and independent Being is sufficient to account for all the phenomena of nature; therefore, from the phenomena, &c.
>
> *No more* than *one* such Being can be *necessarily* inferred to exist.

But though no more than *one* independent being can in this sense of the word *necessarily* exist, it by no means follows from this syllogism, that two or more such beings may not *possibly* exist. It is, indeed, a plain contradiction to say, that two or more self-existent beings are in this sense *necessary*; but surely there is no contradiction in saying, that two or twenty such beings are *possible*. We could not, therefore, by this argument convict a person of absurdity, who should affirm that two or more independent beings *actually* exist. We might, indeed, deny the existence of them all but *one*, because one is sufficient to account for those phenomena, from which alone we know that *any* independent being exists; but because one of them might be supposed to exist *alone*, so that it would be no contradiction to suppose the other not to exist; we know not how the doctor came to affirm, in direct opposition to his own demonstration, that *not one* of them would be necessarily existing.

Necessity, as applied to existence, in the other sense of the word, arises, as we have seen, from the relation which the *actual* existence of the being, of which it may be affirmed, has to the *manner* of that being's existence. It is the same necessity, we are told †, with that which is the cause of the unalterable proportion between two and four; and it is considered as the *formal* cause or *ground* of the existence of an independent being. Were it not for the strange expressions *formal cause* and *ground* of *existence*, we should have no objection to this account of that *necessity* by which a being independent undoubtedly exists: but this kind

† *Answer to the Sixth Letter* from a Gentleman in Gloucestershire.

of

of necessity is a principle which will not support the superstructure which the learned author labours to raise upon it. The same *necessity* which is the cause of the unalterable proportion between *two* and *four*, is likewise the cause of the unalterable proportion between *three* and *six*, between *four* and *eight*, and between *five* and *ten*, &c. But if it can be the cause of so many different proportions of the same kind, why may it not be the *formal cause* or *ground* of existence to as *many independent beings* of the same kind as well as to *one*? The following syllogism, we apprehend, to be legitimate both in mode and figure, and its conclusion is directly contrary to the proposition which the doctor deduces from the same notion of necessity.

> If necessity, considered as a *formal cause* or *ground of existence*, be in *one instance* of its causality the formal cause or ground of existence to *many things* of the same kind, it *may* likewise in *every other instance* of its causality, be the formal cause or ground of existence to many things of the same kind.
>
> But such necessity, in that instance of its causality where it is the formal cause or ground of existence to the unalterable proportion between two and four, *is* the formal cause or ground of existence to *many proportions* of the same kind.
>
> Therefore, the same necessity in that other instance of its causality, where it is said to be the formal cause or ground of existence to *one* independent being, undoubtedly *may be* the formal cause or ground of existence to *many independent beings* of the same kind.

299 Necessity, a dangerous principle.

Thus it appears, that *necessity*, in any sense in which it can be properly affirmed of existence, cannot be the foundation of any argument to prove the impossibility of more than one self-existent being. It is indeed a principle from which we apprehend that no positive conclusion whatever can be deduced by reasoning *à priori*. That necessity of existence may be predicated of a being which is independent and uncreated, is self-evident; because to the *nature* of such a being, existence is essential. But whilst *that nature* itself remains wholly *incomprehensible* by us, it is impossible that we should discover, by our own unassisted reason, whether it can be the nature of *only one*, or of *more than one*, independent being. To argue from necessity, as if it were the cause or ground of existence to such a being, is certainly absurd, if it be not impious; for if that to which existence is essential, does not exist without any cause efficient or formal, we shall be obliged to inquire after a cause or ground of this cause, and thus be involved in all the absurdities and contradictions of an infinite series. We have insisted the longer on this point, because *necessity*, as the foundation of the argument *à priori*, has sometimes been employed to very bad purposes. Attempts have been made from the notion of *necessary* existence, to prove that the Supreme Being cannot be a free agent, and to set the first principles of the religion of nature at variance with those which are revealed in the Scriptures.

300 The unity of God highly probable.

But though we are firmly persuaded that the divine unity cannot be *demonstrated à priori*, we are far from thinking it incapable of any *proof*. On the contrary, the common arguments *à posteriori*, drawn from the *order* and *harmony* of the world, have always satisfied us, and in our opinion must satisfy every person capable of proportioning his assent to evidence, that the Creator and Preserver of such a system has but *one will* and *one intelligence*, and therefore is himself but *one being*. But *proof* is one thing, and *demonstration* is, in the proper sense of the word, another (G). And if we cannot arrive at *absolute* certainty concerning this important truth by the light of nature, we ought to be the more thankful for that revelation, which has put the unity of God past dispute to all who believe the holy Scriptures.

301 God omnipotent.

The being which is self-existent and independent must be also *omnipotent*. That such a being has *active power in some degree*, is shown at the same time and by the same medium that we prove his existence; and since he depends upon no cause for his existence or his power, he cannot depend upon any for the exertion of that power, and consequently no *limits* can be applied to it. Limitation is an *effect* of some *superior cause*, which in the present instance there cannot be: consequently to suppose *limits* where there can be no *limiter*, is to suppose an *effect* without a *cause*. For a being to be *limited* or *deficient* in any respect *, is to be *dependent* in that respect on some *other* being which gave it just so much and no more; consequently that being which in *no respect* depends upon any other is in *no respect* limited or deficient. In all beings capable of increase or diminution, and consequently incapable of *perfection* or *absolute infinity*, *limitation* or *defect* is indeed a necessary consequence of existence, and

* *Notes to King on Evil.*

(G) John Gerhard and John Vossius both cite *Gabriel Biel* as acknowledging the unity of God to be incapable of rigid demonstration; and with the sentiments of that schoolman, those two learned divines profess their own to agree.

Sed Biel (1 Sent. Dist. 2. Q. 10. Art. 3.), statuit "quod tantum *unum* esse Deum, sit *creditum* et *non demonstratum* ratione naturali nobis in via possibili." Id nos ita interpretamur; etiamsi ex *naturæ libro* rationes *non contemnendæ* pro *unitate* divinæ essentiæ asserenda erui possint, eas tamen ad fidei πληροφορίαν cordibus nostris ingenerandum, non satis efficaces esse. Ergo mens prius confirmanda est ex *verbo Dei*, et illustribus testimoniis in quibus se Deus generi humano patefecit: Postea utiliter potest addi consideratio philosophicarum demonstrationum. *Gerhard. Loc. Comm.* tom. i. p. 106.

Dissentit *Gabriel Biel*, qui ante annos hosce 140 *Tubingensi* Gymnasio præfuit. Is censet *probabiles* magis rationes esse quam *evidentes* et *certas*.—Verum esto sane, ut solæ non sint αποδεικτικαι: At magnum iis pondus addit *traditio* vetus; tum autem quod argumenta isthæc, si non prorsus αποδεικτικα, saltem usque adeo *probabilia* sint, ut της πολυθειας patroni nihil ullius momenti adferre valeant; cur plusquam unum statuere deum potius conveniat. *Voss. de Idolatria*, lib. i. c. 2.

f the Being and Attributes of God.

and is only a *negation* of that perfection which is wholly incompatible with their nature; and therefore in these beings it requires no further cause. But in a being *naturally capable* of *perfection* or absolute *infinity*, all *imperfection* or *finiteness*, as it cannot flow from the *nature* of that being, seems to require some *ground* or *reason;* which reason, as it is foreign from the being itself, must be the effect of some other external cause, and consequently cannot have place in the *first cause.* That the self-existent being is *capable* of perfection or absolute infinity must be granted, because he is manifestly the subject of one infinite or perfect attribute, viz. *eternity*, or absolute invariable existence. In this respect his existence has been shown to be perfect, and therefore it *may* be perfect in every other respect also. Now that which is the subject of one finite attribute or perfection, must have all its attributes infinitely or in perfection; since to have any perfections in a finite limited manner, when the subject and these perfections are both *capable* of strict *infinity*, would be the forementioned absurdity of positive limitation without a cause. To suppose this eternal and independent being limited *in* or *by* its own *nature*, is to suppose some *antecedent nature* or *limiting quality* superior to that being, to the existence of which no *thing*, no *quality*, is in any respect *antecedent* or *superior.* And to suppose that there is no such thing as *active power* in a being which is evidently the fountain of all power, is the grossest of all absurdities. The same method of reasoning will prove knowledge and every other perfection to be *infinite* in the Deity, when once we have proved that perfection to belong to him at all; at least it will show, that to suppose it limited is unreasonable, since we can find no manner of *ground* for limitation in any respect; and this is as far as we need go, or perhaps as natural light will lead us.

302 mnipotence can every thing which does not imply a contradiction.

Of the omnipotence of the supreme Being some philosophers as well theists as atheists, have talked very absurdly. *Hobbes* *, with a view to make this attribute appear impossible and ridiculous, affirms "that God by his omnipotence or infinite power could turn a tree into a syllogism." And *Des Cartes* †, though certainly no atheist, childishly asserts, that all things whatever, even abstract truth and falsehood, do so depend upon the arbitrary will and power of God, as that if he had pleased, "twice two should not have been four, nor the three angles of a plain triangle equal to two right ones." But the true motion of Omnipotence, so far from implying a power to turn a tree into a syllogism, or to make twice two not equal to four, implies only that the being possessed of it can actually perform whatever can be conceived by the most perfect understanding; conception in this case being the measure of possibility. Now every thing may be conceived by a mind sufficiently enlarged which does not involve in it a direct contradiction; but what we clearly discern to imply a contradiction, such as that a thing may be and not be at the same instant, cannot be conceived by any intellect, or made to exist by any power.

* *Leviath.* cap. 3.

† *Respons.* ad *Objectiones Sextas*, § 6.

And thus has this attribute of the Divinity been always stated, not only by the wiser Christians, but also by most of the ancient philosophers themselves, who expressly admit that "nothing is exempted from the divine power, but only to make that which hath been done to be undone (H)."

303 Creation possible to Omnipotence.

And here it may be asked, Whether creation, in the proper sense of the word (see CREATION), be within the compass of infinite power. All the ancient philosophers, who were unenlightened by the rays of divine revelation, held that it is not *; grounding their opinion upon this maxim, *Ex nihilo nihil fit.* But the maxim will support no such conclusion.—The ancients, or at least the Peripatetic school, with the metaphysics of which we are best acquainted, considered four kinds of causes, the *efficient*, the *material*, the *formal*, and the *final;* and though they extended the maxim to the first *two*, if not to all these causes, it is a self-evident truth only when applied to the *efficient cause.* Without the actual exertion of *power*, it is indeed most certain that nothing could be brought into existence; but it is so far from being clear that pre-existent matter, or, as Aristotle chose to express himself, a *material cause*, must be supposed for infinite power to operate upon, that, we think, every man may find complete evidence of the contrary in himself. That sensation, intelligence, consciousness, and volition, are not the result of any modifications of figure and motion, is a truth as evident as that consciousness is not swift, nor volition square. If then these be the powers or properties of a being distinct from matter, which we think capable of the completest proof, every man who does not believe that his mind has existed and been conscious from eternity, must be convinced that the power of creation has been exerted in himself. If it be denied that there is any immaterial *substance* in man, still it must be confessed, that, as matter is not essentially conscious, and cannot be made so by any particular organization, there is some real *thing* or *entity*, call it what you please, which has either existed and been conscious from eternity, or been in time brought from non-entity into existence by an exertion of infinite power.

* See *Mosheim's Dissertation on this Subject, in his Edition of Cudworth's Intellectual System.*

To this perhaps some one may object, that upon our own supposition of the inability of the human mind to exert its faculties but in union with some material and organized system, the mind of every man may have existed from eternity without being conscious of its own existence; and that, therefore, we have in ourselves no evidence of *creation*, but only of the union of two self-existent substances, which, in their prior state, had been distinct and separate from each other. But such an objection as this, we beg leave to reply, can arise from nothing but misapprehension of our hypothesis, and of the reasons by which we think it supported. We suppose, that to the exertion of the human faculties, a body of some kind or other may be necessary as an instrument, not merely from what we observe of the dependence of perception

(H) Το δε γεγονος ουκ ενδεχεται μη γενεσθαι· διο αγαθως Αγαθων.
Μονου γαρ αυτου και θεος στερισκεται,
Αγενητα ποιειν, ἁττ' αν ἠ πεπραγμενα. *Arist. ad Licomach.* lib. vi. cap. 2.

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tion and memory on the state of the brain, but because we cannot conceive a Creator of infinite wisdom and goodness to immerse in systems of matter, minds to which he knows that such systems must be always useless and often hurtful. We believe, therefore, that our souls and bodies were created and formed for each other; but as our present adversaries admit not of a Creator, we must ask them, How their self-existent souls have been disposed of from eternity, and by what power they have all in due succession been united each to its proper body? As before the union they were not conscious, they could not unite themselves; and to suppose them united by some superior intelligence, is to suppose them in some respects dependent on that intelligence, which seems not to accord with their self-existence. Whatever is self-existent and eternal must be independent; and if possessed of any power, cannot be conceived to have that power limited.—We repeat, therefore, that every man has in himself sufficient evidence that creation is possible; for if infinite power can create an immaterial and percipient being, it may surely be supposed capable of creating dead and unintelligent matter.

But the creation of the material system may be shown to be in the highest degree probable by other arguments. The same reasoning which proves the impossibility of an infinite series and of eternal time, proves that the universe cannot have existed from eternity in its present state. But if it has not existed from eternity in its present state, it belongs to the opponents of creation to say what was its former. We talk indeed of *chaos;* but such language, when a Creator is not admitted, is most unphilosophical trifling. It appears from the most accurate inquiries that have been made into the substance and essence of body *, that the atoms of which each mass is composed are held together by a foreign force. If by chaos be meant matter, when this force is supposed to be removed, we must beg leave to say, that of such a substance we have neither idea nor notion, and cannot distinguish it from nonentity. The original atoms of matter, we believe indeed to require no other agency to keep each entire than that *fiat* by which it was created; but still, as those atoms are conceived to be solid and extended, they must be capable of division by infinite power; and if that *fiat* or influence which makes them solid and extended were removed, they would lose solidity and extension, and of course become nothing. So far is it, therefore, from being true, that the creation of matter appears to be impossible, that we are compelled by every thing that we know of it to believe that matter cannot possibly be self-existent.

* *Baxter's Inquiry into the Nature of the Human Soul.*

"Because it is undeniably certain, concerning ourselves (says Cudworth †), and all imperfect beings, that none of these can create any *new substance*, men are apt to measure all things by their own scantling, and to suppose it universally impossible for any power whatever thus to create. But since it is certain, that imperfect beings can themselves produce *some things* out of nothing pre-existing, as *new cogitations*, *new local motion*, and *new modifications* of things corporeal, it is surely reasonable to think that an absolutely perfect Being can do *something more*, i. e. create *new substances*, or give them their whole being. And it may well be thought as easy for God or an Omnipotent Being, to make a whole world, matter and all, ἐξ οὐκ ὄντων, as it is for us to create *a thought* or to move a finger, or for the sun to send out rays, or a candle light; or lastly, for an opaque body to produce an image of itself in a glass or water, or to project a shadow: all these imperfect things being but the *energies*, *rays*, *images*, or *shadows*, of the Deity. For a substance to be made out of nothing by *God*, or a *Being infinitely perfect*, is not for it to be made out of nothing in the impossible sense, because it comes from him who is *all*. Nor can it be said to be impossible for any thing whatever to be made by that which hath not only *infinitely greater perfection*, but also *infinite active power*. It is indeed true, that infinite power itself cannot do things in their own nature impossible; and, therefore, those who deny creation, ought to prove, that it is absolutely impossible for a *substance*, though not for an *accident* or *modification*, to be brought from non-existence into *being*. But nothing is in itself impossible, which does not imply a contradiction: and though it be a contradiction for a thing to be and not to be at the same time, there is surely no contradiction in conceiving an imperfect being, which before was not, afterwards to be." To call in question the possibility of creation, because we have no *adequate conception* how a thing can be brought into existence, would be in the highest degree absurd; for it may be doubted, whether we have *adequate* conceptions of any thing except our own ideas and their various relations (1).

† *Intellectual System*, Book i. chap. 5.

304 God a free agent; but

That Being which is self-existent, omnipotent, and omniscient, is not a *necessary*, but a *free* agent; for *active*

(1) "Ridicula foret et inepta ejus temeritas, qui corporum ideo creationem sibi duceret negandum esse, quod ejus creationis *claram et perspicuam notionem* effingere cogitatione nobis haud licet. Infinita enim est rerum copia, quarum perspicuis et apertis caremus notionibus. Et si omnia neganda continuo nobis essent, quorum confusam tantum et imperfectam consequi possumus notionem, omnia fere nobis essent neganda, exceptis *relationibus*, quas inter notiones quasdam abstractas esse intelligimus. Quis interiorem sibi naturam rerum, tam corporum, quam spirituum, cognitam esse dixerit? Et esse tamen has naturas, omni plane dubitatione vacat. Quis quemadmodum altera harum naturarum agat in alteram, sese scire, affirmet? Quis causas sibi patere, propter quas hi vel illi effectus, quos videmus quotidie contingere, à certis veniant corporibus, jure glorietur? Nec tamen quisquam est, qui vel illam animæ in corpus operationem, vel hos effectus in dubium revocare ausit. Teneamus igitur ea, quæ certo novimus, nec idcirco nos ab illis dimoveri patiamur, quod multa rursus sunt, quorum naturam ignoramus; contra multa nos fugere et cognitionem nostram superare, æquo at tranquillo feramus animo. *Joannis Clerici contra eos qui negant, ex nihilo ulla ratione fieri posse aliquid, observationes; in Moshemii edit. Intellec. Syst.*

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tive power implies *freedom*, and *infinite* power *infinite* freedom. What, therefore, hath no bounds set to its power, what can have no opposition made to its will, nor restraint laid on its actions, must both will and act freely. "If the Supreme Cause were not a being endowed with liberty and choice, but a mere necessary agent, then would it follow, as Dr Clarke well observes *, that nothing which is not, could *possibly* have been; and that nothing which is, could *possibly* not have been; and that no mode or circumstance of the existence of any thing could *possibly* have been in any respect otherwise than it now actually is. All which being evidently most false and absurd; it follows, on the contrary, that the Supreme Cause is not a mere necessary agent, but a Being endued with liberty and choice."

Demonstration of the Being and Attributes of God.

Cooper's Tracts.

To this reasoning it has been lately replied †, that "Clarke must have known, that all those who contend against the free agency of the Deity, do of course acknowledge, that nothing could have happened, or does happen, or will happen, but what actually has happened, or doth happen, or will happen; and that it is most false and absurd to deny it." It is, therefore, according to the necessarians, absolutely impossible, that at present there could exist upon this earth more or fewer persons than are now actually alive; that the earth could move in any other direction than from west to east; or that there could be more or fewer planets in the solar system. Yet is it most certain, that there *have been fewer persons* on the earth than there are now; that there is not a cultivated country in Europe which could not contain *more* people than now inhabit it; that the comets move in very different directions from that of west to east; and that as, till very lately, we *conceived* only six primary planets in the system, it is evidently *possible* that the system *might contain* no more. Upon the supposition, therefore, that the Supreme Being acts under a physical necessity, the same things are possible and not possible at the same time, which is the grossest of all absurdities. It might have been objected with much more plausibility, that the First Cause cannot possibly be free, because he must needs do always what is best in the whole; but it will be seen by and by, that among different created systems, there is no reason for supposing any one absolutely *best*.

305 Himself unchangeable.

But though this Being be *free*, and as such the author of *change* in other beings, yet he must himself *be unchangeable*; for all changes have a beginning, and consequently are effects of some *prior causes*. But there can be nothing prior to the existence of this Being, as he is *eternal*; neither any *cause* of it, as he is *independent*; nor consequently any *change* in it, except we could suppose him to *change himself*, which is the same absurdity as to *produce* himself, i. e. to be at *the same time both effect* and *cause*.

306 Omniscience, &c. proved in a different manner. Notes to ...ing on ...il.

Omniscience, as well as some of the foregoing attributes of the Supreme Being, may perhaps be more easily deduced thus ‡. We find in ourselves such qualities as *thought* and *intelligence*, *power* and *freedom*, &c. for which we have the evidence of consciousness as much as for our own existence. Indeed it is only by our consciousness of these that our existence is known to ourselves. We know likewise that these are *perfections*, and that to have them is better than to be without them. We find also that they have not been in us from eternity. They must, therefore, have had a *beginning*, and consequently some *cause*, for the very same reason that a *being* beginning to exist in time requires a cause. Now this cause, as it must be *superior* to its *effect*, must have those perfections in a *superior* degree; and if it be the *first cause*, it must have them in an *infinite* or *unlimited* degree, since *bounds*, or *limitation* without a limiter, would, as we have already shown, be an *effect* without a *cause*.

It is indeed obvious, that the *omniscience* of the Supreme Being is implied in his very existence. "For all things being not only present to him, but also entirely *depending* upon him, and having *received* both their *being* itself and all their powers and faculties *from him*, it is manifest that as he knows all things that are, and penetrates every part of their substance with his all-seeing eye, so must he likewise know *all possibilities* of things, that is, all effects that *can* be. For, being alone self-existent, and having alone given to all things all the powers and faculties with which they are endued, it is evident that he must of necessity know perfectly what all and each of these powers and faculties, *which are derived wholly from himself*, can possibly produce. And seeing at one boundless view, or more properly in his own ideas, all the possible compositions and divisions, variations and changes, circumstances and dependencies of things, all their possible relations one to another, and their dispositions or fitnesses to certain and respective ends, he must without possibility of error know exactly what is best and properest in every one of the numberless possible cases, or methods of disposing things; and understand perfectly how to order and direct the respective means to bring about what he so knows to be in its kind, or on the whole, the best and fittest in the end. This is what is meant by infinite wisdom, or omniscience *;" and it has been readily admitted by every man who has believed in the existence of a God, as the creator and preserver of all things.

* *Clarke's Demonstration*, &c.

307 God foreknows the actions of free agents.

Doubts, however, have been entertained by theists, and pious theists, whether omniscience itself can certainly foreknow what are called contingent events, such as the actions of free agents; and some few there are professing to be even Christians, who have boldly pronounced such knowledge to be impossible. That we have no adequate notion *how* events, which are called contingent, can be certainly foreknown, must indeed be granted; but we are not, therefore, authorized to say that such knowledge is impossible, unless it can be clearly shown to imply a contradiction. They who suppose that it implies a contradiction, must likewise suppose, that, where there is not a chain of necessary causes, there can be no certainty of any future event; but this is evidently a mistake. "For let us suppose that there is in man a power of beginning motion, and of acting with what has been of late called *philosophical* freedom; and let us suppose farther that the actions of such a man cannot possibly be foreknown; will there not yet be in the nature of things, notwithstanding this supposition, the same *certainty of event* in every one of the man's actions, as if they were ever so fatal and necessary? For instance, suppose the man, by an internal principle of motion, and an absolute freedom of mind, to do some particular action *to-day*, and suppose it was

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was not possible that this action should have been foreseen *yesterday*, was there not nevertheless the same *certainty of event* as if it had been foreseen, and absolutely necessary? That is, would it not have been as *certain a truth* yesterday, and from eternity, that this action was in event *to be performed to-day*, notwithstanding the supposed freedom, as it is now a *certain and infallible truth* that it is performed? Mere *certainty of event*, therefore, does not in any measure imply *necessity* *." And surely it implies no contradiction to suppose, that every future event which in the nature of things is *now certain*, may *now be certainly known* by that intelligence which is omniscient. The *manner* how God can foreknow future events, without a *chain of necessary causes*, it is indeed impossible for us to explain: yet some sort of *general notion* of it we may conceive. "For, as a man who has no influence over another person's actions, can yet often perceive beforehand what that other will do; and a wiser and more experienced man, with still *greater probability* will foresee what another, with whose disposition he is perfectly acquainted, will in certain circumstances do; and an angel, with still *less degrees of error*, may have a further prospect into men's future actions: so it is very reasonable to conceive, that God, without influencing men's wills by his power, or subjecting them to a chain of necessary causes, cannot but have a knowledge of future free events, as much *more certain* than men or angels can possibly have, as the *perfection* of *his* nature is greater than that of *theirs*. *The distinct manner how* he foresees these things we cannot, indeed, explain; but neither can we explain the *manner* of numberless other things, of the reality of which, however, no man entertains a doubt †." We must therefore admit, so long as we perceive no contradiction in it, that God always knows all the free actions of men, and all other beings endued with liberty; otherwise he would know many things now of which he was once ignorant, and consequently his *omniscience* would receive addition from events, which has been already shown to be contrary to the true notion of infinity.—In a being incapable of change, knowledge has nothing to do with *before* or *after*. To every purpose of knowledge and power, all things are to him equally present. He knows perfectly every thing that is, and what to us is future he knows in the very same manner as he knows what to us is present.

* *Clarke's Demonstration.*

† *Clarke's Demonstration, &c.*

308 God infinitely perfect, all-sufficient, and omnipresent.

Thus have we demonstrated the necessary existence of a being who is *eternal*, *independent*, *unchangeable*, *omnipotent*, *free in his actions*, and *omniscient*; and this is the being whom we worship as GOD. *Eternity*, *independence*, *immutability*, *omnipotence*, *liberty*, and *omniscience*, which seem to be all the *natural* attributes which we can discover in the divine nature, as they are conceived to be differently combined, make us speak of him in different terms. His enjoying in an absolute manner every conceivable power or perception, makes us call him a Being *infinitely perfect*. His being capable of no want, defect, or unhappiness of any kind, denotes him to be *all sufficient in himself;* and the unlimited exercise of his knowledge and power, demonstrates him to be *omnipresent*. That such a Being must be incomprehensible by us, and by every creature, is a truth self-evident; and yet in all ages men of the best intentions have been vainly attempting this impossibility. The manner of his omniscience, for instance, has been the subject of much disputation among those who ought to have reflected that they know not how their own minds were present to their own bodies.—The celebrated Dr Clarke and his adherents, who considered space as the *sine qua non* of all other things, insisted, that God must be infinitely extended; and that, as wherever his substance is, there his attributes must be, it is thus that his knowledge and power are present with every creature. But this notion labours under insuperable difficulties.

309 The manner of the divine omnipresence incomprehensible.

For "if the Divine substance be infinitely extended, then will there be part of it in this place and part in that. It must be commensurate with all particular beings, so that some will occupy more and some less of its dimensions. By this account it will be very proper and philosophical to say, that God is not in *heaven*, but only a *part* of him: and that an *elephant* or a *mountain*, a *whale* or a wicked *giant*, have more of the essence or presence of God with them, than the *holiest* or *best* man in the world, unless he be of equal size: all which, as has been well observed *, are at least harsh and grating expressions. As the attributes of the Divine Being must be considered in the same manner with his substance, we shall likewise, upon this notion of omnipresence, have a part of his knowledge and power in this place, and a part of them in that; and of these parts the one must be greater or less than the other, according to the dimensions of the place with which it is commensurate; which is a supposition that appears to us harsher, if possible, than even the former.

* *Watt's Essays*, and *Law's Inquiry into the Ideas of Space, Time, Immensity*, &c.

"Should it be said that the divine attributes are not to be considered as having parts (though we see not how they can be considered otherwise than as their subject), they must then exist *completely* in every point of this immense expansion. Be it so; and what follows? Why, every point of this infinitely expanded being will be omniscient and omnipotent by himself; an inch of it will have as much wisdom and power as a yard, a mile, or the whole; and, instead of one infinite wisdom and power, we shall have millions: For as these parts of the substance are conceived *distinctly*, and one individual part is not another, so must the attributes be likewise conceived, and the individual power and knowledge of one part be distinct from that of another." And if so, it follows, that one point of this expanded being has equal power and intelligence with the whole; so that the notion of extension being *necessary* to God's presence with every creature, involves in it the most palpable contradiction. That God is at all times and in all places so present with every creature as to have an absolute knowledge of and power over it, is indeed capable of the strictest demonstration; but we think it great presumption to assign the particular *mode* of his presence, especially such a one as is neither agreeable to the nature of an absolutely perfect Being, nor in the least necessary to the exercise of any one perfection which he can be proved to possess. Philosophers and divines have offered several names for the manner in which God is present with his works; but we choose rather to confess, that the *manner* of his presence is to us, and probably to every creature, wholly incomprehensible. Nor need we be surprised or staggered at this, when we reflect that the manner in which our own minds are present

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present with our bodies is to us as incomprehensible as the manner in which the supreme Mind is present with every thing in the universe. That our minds have a power over our limbs, we know by experience: but that they are not extended or substantially diffused through them, is certain; because men daily lose arms and legs, without losing any part of their understanding, or feeling their energies of volition in the smallest degree weakened. But we need pursue this subject no farther. It has been confessed by one of the most strenuous advocates* for the extension of the Deity and all minds, that "there is an incomprehensibleness in the *manner* of every thing, about which no controversy can or ought to be concerned."

* Mr Jackson's Existence and Unity, &c. page 110.

310 God's moral attributes result from his natural perfections.

The moral attributes of God may be deduced from his natural ones, and are immediate consequences of them when exercised on other beings. They may be termed his *secondary relative* attributes, as they seem to be the perfection of his *external acts* rather than any *new internal* perfections. And though the existence of any moral quality or action is not capable of strict *demonstration*, because every moral action or quality, as such, depends upon the *will* of the agent, which must be absolutely free; yet we have as great assurance that there are moral qualities in God, and that he will always act according to these qualities, as the nature of the thing admits; and may be as well satisfied of it, as if it were capable of the most rigid demonstration. This important point, however, cannot be so clearly or so firmly established by abstract reasoning as by taking a scientific view of the works of creation, which evince the goodness, holiness, and justice of their Author, as well as his perfect wisdom and infinite power. The consideration, therefore, of the moral attributes of God, together with his providence, and the duties thence incumbent on man, is the proper business of other articles (see RELIGION, THEOLOGY, and MORAL *Philosophy*.

311 How they ought to be conceived.

At present we shall only observe, that by reasoning *à priori* from his existence and his natural perfections, we must necessarily infer that his actions are the result of unmixed benevolence. Every wise agent has some end in view in all his actions; it being the very essence of folly to act for no end: but there cannot be an end of action which is not either selfish or benevolent. Selfishness is the offspring of want and imperfection, and is therefore the source of most *human* actions; because men are weak and imperfect beings, capable of daily additions to their happiness. When the thief plunders a house at midnight, when the highwayman robs a traveller on the road, and even when the assassin murders the man who never injured him; it will be found that their actions spring not from an innate desire to inflict misery upon others, but from a prospect of reaping advantage to themselves. The object of the thief and the robber is obvious: it is to gain money, which is the mean of procuring the comforts of life. Even the assassin has always the same selfish end in view: either he is *bribed* to commit the murder, or he fancies that his horrid deed will remove an *obstacle* from the way to his own happiness. But they are not vicious men *only* who act from selfish considerations: much of human *virtue*, when traced to its source, will be found to have its origin in the desire of happiness. When a man gives his money to feed the hungry and to clothe the naked, he believes that he is acting agreeably to the will of Him to whom he and the poor stand in the same relation; and he looks for a future and eternal reward. By continuing the practice, he soon acquires the habit of benevolence; after which, indeed, he looks for no further reward, when performing particular actions, than the immediate pleasure of doing good. This selfishness of man is the necessary consequence of his progressive state. But the Being who is independent, omnipotent, omniscient, and, in a word, possessed of every possible perfection, is incapable of progression, or of having any accession whatever made to his happiness. He is immutable; and must of necessity have been as happy from eternity, when existing alone, as after the creation of ten thousand worlds. When, therefore, he willed the existence of other beings, he could have nothing in view but to communicate some resemblance of his own perfections and happiness. That he had *some* end in view, follows undeniably from his infinite wisdom. That he could not have a *selfish* end, follows with equal certainty from his own infinite perfections; and as there is no medium, in the actions of a wise Being, between selfishness and benevolence, we must necessarily conclude, that the creation was the result of unmixed benevolence or perfect goodness. The other moral attributes of the Deity, his justice, mercy and truth, ought therefore only to be considered as so many different views of the same *goodness* in the *Creator*, and various sources of *happiness* to the *creature*. These are always *subordinate* to and *regulated* by this one principal perfection and brightest ray of the Divinity.

"Thus we conceive his *justice* to be exerted on any being no farther than his goodness necessarily requires, in order to make that being, or others, *sensible* of the *heinous nature* and *pernicious effects of sin* *, and thereby to bring them to as great a degree of happiness as their several natures are capable of. His *holiness* hates and abhors all wickedness, only as its necessary consequences are absolute and unavoidable misery; and his veracity or faithfulness seems to be concerned for truth, only because it is connected with and productive of the happiness of all rational beings; to provide the properest means for attaining which great end, is the exercise of his *wisdom*." Such is the view of God's moral attributes, which the abstract contemplation of his natural perfections necessarily gives; and whether this way of conceiving them be not attended with less difficulty than the common manner of treating them under the notion of two infinites *diametrically opposite*, must be left to the judgment of the reader.

* *Notes to King on Evil.*

312 The origin of evil.

But if the Creator and supreme Governor of all things be a Being of infinite power, perfect wisdom, and pure benevolence, how came evil into the works of creation? This is a question which has employed the speculative mind from the first dawning of philosophy, and will continue to employ it till our faculties be enlarged in a future state, when philosophy shall give place to more perfect knowledge. To these meditations, as has been well observed ‡, humanity is not equal. Volumes have been written on the subject; but we believe that the following extract from Dr

‡ *Johnson's Review of a free Inquiry into the Origin of Evil.*

Dr Clarke contains all that can be advanced with certainty, and all that is necessary to vindicate the ways of God to man.

"All that we call evil (says that able reasoner †), is either an *evil of imperfection*, as the want of certain faculties and excellencies which other creatures have; or *natural evil*, as pain, death, and the like; or *moral evil*, as all kinds of vice. The *first* of these is not properly an evil: for every power, faculty, or perfection, which any creature enjoys, being the free gift of God, which he was no more obliged to bestow than he was to confer being or existence itself, it is plain, that the want of any certain faculty or perfection in any kind of creatures, which never belonged to their nature, is no more an evil to them, than their never having been created or brought into being at all could properly be called an evil." To this we may add, that as no created being can be self-existent and independent, imperfection is unavoidable in the creation, so that the evil of defect (as it is most absurdly called) must have been admitted, or nothing could ever have existed but God. "The *second* kind of evil, which we call *natural* evil, is either a necessary consequence of the former, as *death* to a creature on whose nature immortality was never conferred; and then it is no more properly an evil than the former: Or else it is counterpoised in the whole with as great or greater good, as the *afflictions and sufferings of good men*: and then also it is properly no evil. Or else it is a *punishment*; and then it is a necessary consequence of the *third* and last sort of evil, viz. *moral evil*. And *this* arises wholly from the abuse of *liberty*, which God gave to his creatures for other purposes, and which it was reasonable and fit to give them for the perfection and order of the whole creation: only they, contrary to God's intention and command, have abused what was necessary for the perfection of the whole, to the corruption and depravation of themselves. And thus have all sorts of evils entered into the world, without any diminution to the infinite goodness of its Creator and Governor."

† *Demonstration of the Being and Attributes of God.*

313
Whether the present be the best system possible.

But though evil could not be totally excluded from the universe, are we not authorized to infer, from the infinite power, wisdom, and goodness of the Creator, that the present system is upon the whole the very best system possible? Undoubtedly we are, if of possible systems there *can be a best*: but this is so far from being evident, that we think it implies a contradiction. A best of beings there is, viz. God, who is possessed of infinite perfections; but there cannot be a best of creatures or of created systems. To prove this, we need only reflect, that wherever creation stops, it must stop infinitely short of infinity; and that how perfect soever we conceive any creature or system of creatures to be, yet the distance between that and God is not lessened but continues infinite. Hence it follows that the nature of God and his omnipotence is such, that whatever number of creatures he has made, he may still add to that number; and that however good or perfect the system may be on the whole, he might still make others equally good and perfect.

314
Origin of that question.

The dispute, whether a being of infinite power, wisdom, and benevolence, must be supposed to have created the *best possible system*, and the embarrassment of men's understandings about it, seem to have arisen from their taking the words *good*, *better*, and *best*, for absolute qualities inherent in the nature of things, whereas in truth they are only relations arising from certain appetites. They have indeed a foundation, as all relations have, in something absolute, and denote the thing in which they are founded; but yet they themselves imply nothing more than a relation of congruity between some appetite and its objects. This is evident; because the same object, when applied to an appetite to which it has a congruity, is good; and bad, when applied to an appetite to which it has no congruity. Thus, the earth and air to terrestrial animals are good elements, and necessary to their preservation: to those animals the water is bad, which yet affords the best receptacle to fishes. *Good*, therefore, being relative to appetite, that must be reckoned the best creature by us which has the strongest appetites, and the surest means of satisfying them all, and securing its own permanent happiness. And though the *substance* of creatures is chiefly to be regarded as contributing to their perfection, yet we have no way of measuring the perfection of different substances but by their qualities, *i. e.* by their appetites by which they are sensible of good and evil, and by their powers to procure those objects from which they receive that sense of things which makes them happy.

315
No system absolutely best.

It is plain, therefore, that whatever system we suppose in nature, God might have made another equal to it; his infinite wisdom and power being able to make other creatures equal in every respect to any that we know or can conceive, and to give them equal or stronger appetites, and as certain or more certain ways of satisfying them. We see in many cases, that very different means will answer the same end. A certain number of regular pyramids will fill a space; and yet irregular ones will do it as well, if what we take from the one be added to another; and the same thing may be done by bodies of the most irregular and different figures in the same manner: and therefore we may very well conceive, that the answering of appetites, which is all the *natural good* that is in the world, may as well be obtained in another system as in this; provided we suppose, that where the appetites of the sentient beings are changed, the objects are also suited to them, and an equal congruity among the parts of the whole introduced. This is so easily conceived, that in an indefinite number of possible worlds, we do not see why it may not be done in numberless ways by infinite power and wisdom.

316
God not necessitated by his goodness to create the present in preference to all other worlds.

If then it be plain, that there might have been many other worlds, or even but one, equal to this in all respects as to goodness, there could be no necessity, either physical or moral, that God should create the one rather than the other; because nothing could make the one better, or to him more agreeable, than the other, but his own free choice. Either, therefore, God must be possessed of absolute freedom, or, among a number of possibilities equally perfect, he could not have made a choice, and so nothing would ever have been created. It is not, then, as Leibnitz and others argue, the natural and necessary goodness of some particular things, *represented by the divine ideas*, which determines God to prefer them to all others, if understood of his *first* act of producing them; but it is is his own free choice which, among many equal *potential* goods, makes some things *actually* good, and determines them into existence. When those are once supposed to exist, every thing or action becomes good which tends to their happiness and preservation; and to suppose their all-perfect Author to have any other end in view than their preservation and happiness, is the same absurdity as to suppose that knowledge may produce ignorance; power, weakness; or wisdom folly.

We have now finished what we proposed under the article Metaphysics. It has swelled in our hands to a large extent; and yet it can be considered as little more than an introduction to that science, which comprehends within its wide grasp every thing existing. The reader who wishes to pursue these interesting speculations, should study diligently the authors whom we have consulted, and to whom we have been careful to refer in the margin. Were we to make a selection, we should without hesitation recommend Aristotle and Plato among the ancients; and Cudworth, Locke, Hartley, and Reid, among the moderns. These philosophers, indeed, on many points, differ exceedingly from one another; but he who wishes not to adopt opinions at random, should know what can be said on both sides of every question.

METAPLASMUS, in *Grammar*, a transmutation or change made in a word, by adding, retrenching, or altering a syllable or letter thereof.

METAPONTUM, or METAPONTIUM, in *Ancient Geography*, a town of Lucania, on the Sinus Tarentinus, to the west of Tarentum; built by the Pylians who returned from Troy; and where Pythagoras is said to have taught in the time of Servius Tullius. *Metapontini*, the people; who pretended to show in a temple of Minerva, the tools with which Epeus built the wooden horse, (Justin). Now a tower, called *Torre di Mare*, in the Basilicata of Naples.

METASTASIO, L'ABBE PIERRE BONAVENTURE, a celebrated Italian poet, whose real name was *Trapassi*, was born at Assise, on January 3d, 1698. His talent for poetry was first unfolded by the reading of Tasso; and he began to compose verses at ten years of age. " A prodigy of this nature (says Metastasio) made such an impression on my master, the celebrated Gravina, that he thenceforth considered me as a plant worthy of being cultivated by his own hands." Metastasio was only fourteen years of age when he composed his tragedy entitled *Il Giustino;* in which he appears too close and scrupulous an imitator of the Grecian drama. Our young poet unfortunately lost his patron in 1717; who left him his heir, " as being a young man of the most promising abilities." Metastasio, at the age of nineteen, being, in consequence of this inheritance, superior to those wants which repress the exertions of genius, and to which men of abilities are too often subject, gave full scope to his inclination for poetry. He began his dramatic career with the *Didonne Abandonnata*, which was acted at Naples in 1724; the music was composed by Sarro. He soon acquired such celebrity, that in 1729 he was invited to Vienna by the emperor Charles VI.; who appointed him imperial poet, and granted him a pension of 4000 florins. From that time some of his works were presented at every court festival; and notwithstanding the extreme magnificence of these entertainments, they would now be forgotten were it not for the verses which he composed upon the occasion. The courts of Vienna and Madrid vied with each other in the presents which they conferred upon him. From Maria Theresa he received a snuff-box and a port-folio set with diamonds, and a golden candlestick with a screen. Ferdinand VI. king of Spain, informed of the great merit of Metastasio by Farinelli, of whom he was a passionate admirer, sent him a present of a casket mounted with gold, and furnished with the different implements of writing. This favourite of kings and of the muses was of a cheerful temper, and was exceedingly temperate: to this he was probably indebted for the uninterrupted health which he enjoyed, and for the entire possession of his senses and faculties to the most advanced period of old age. He took his meals, arose, and went to bed, always at stated hours. This exactness and order were scrupulously observed even in the most trifling actions of his life. He used to say in jest, that he dreaded hell for no other reason but because it was a place *ubi nullus ordo, sed sempiternus horror inhabitat*. He had even his stated hours for making verses; to which he scrupulously adhered, without waiting for the moment of poetical enthusiasm. He was equally regular in the duties of the Christian as in the labours of the scholar. His behaviour was that of a true philosopher: his ambition extended no farther than the attainment of literary fame; and he despised every civil mark of distinction. When Charles VI. offered him the title of *Count* or of *Baron*, which add no real worth or dignity to the possessor, but frequently make him appear in a more ridiculous light, he instantly begged the favour that he would allow him still to continue *Metastasio*. The empress Maria Theresa afterwards wished to bestow upon him the small cross of St Stephen; but he excused himself on account of his age, which would prevent him from assisting at the festivals of the order. He was attacked by a fever on the 2d of April 1782; and he died on the 12th of the same month, at the age of 84. Before his death he received the sacrament according to the form of the Romish church; and Pius VI. who was then at Vienna, sent him his apostolical benediction *in articulo mortis*. He left about 150,000 florins. He composed a great number of tragic operas, and several small dramatic pieces which have been set to music. We have different editions of them in 4to, 8vo, and 12mo; and M. Richelet has published a translation of them into French, in 12 vols. small 12mo.

The greatest part of Metastasio's writings will confer immortality on their author. His dialogue is natural,

tural, simple, and easy; his style is always pure and elegant, and sometimes sublime and pathetic. His subjects are noble, interesting, and excellently adapted for representation. He was perfectly acquainted with the resources of his art, and has subjected the opera to rules. He stripped it of its machinery, and of the marvellous, which was fitted to excite the gaze of astonishment, but which gave no instruction to the understanding, and made no impression on the heart. His descriptions are copied from nature; the situations of his characters never fail to raise an interest in the reader, and often excite the tear of pity. His fables are celebrated; his characters are noble and well supported; his plots are excellently conducted, and happily unravelled. "There are scenes (says Voltaire) worthy of Corneille when he does not declaim, and of Racine when he is not feeble." His operas, in point of the pathetic, may be compared with our finest tragedies; and may be read with great pleasure, independent of the charms of the music. We must not, however, expect to find in Metastasio that exact regularity, and that fertile simplicity, which constitutes the excellence of some of our tragic poets: But though he sometimes transgresses the unities of time and place, he always preserves the unity of interest. Notwithstanding all these advantages, some critics will not allow him the merit of invention, which is the first qualification of a poet. They consider him only as a successful imitator of the French tragic writers, from whom a great part of his beauties are borrowed, and place him at the head of the finest wits in Italy, but deny that he possessed genius. He was a fond admirer of the ancients; and this admiration, increasing with the solidity of his understanding, continued to the last period of his life. He recommended reading them, as he himself had done, in a chronological order. His memory was excellent, and continued unimpaired even in old age. Horace was his favourite author, and he could repeat almost the whole of his verses. Metastasio, who, as we have observed, was the pupil of the celebrated Gravina, added a gentleness of character peculiar to himself to the accuracy of thinking and great erudition of his master. His abilities and fame were respected by the critics in general; and whereas the life of most men of letters is one continued warfare, his days happily glided away in tranquillity and peace. The circumstance which occasioned the change of his name is thus related in a late anecdote: "Gravina's barber, who, like most of his profession, was a great talker, one day informed him, that in the *Place de la Valicella*, where he had his shop, a young boy came every evening, and sung extempore verses of his own composition, so harmonious and elegant that all the passengers stopped to listen to them. Gravina, upon this information, added one to the number of the young poet's audience, and found the verses so superior to the idea which he had formed of them from the account of the barber, and so much above the capacity of a child of ten or eleven years of age, that he instantly determined to undertake the cultivation of so promising a plant. His first care was to put the young *Trapassi* (which was the boy's name) to school; but apprehending that the ordinary methods of education might check the progress of so uncommon talents, he took him home to his own house, and changed his name into *Metastasio*, which signifies the same thing in Greek. In short, by a plan of education and by instructions suited to his genius, Gravina laid the foundation of that reputation which he predicted, and which Metastasio now enjoys." *Vies des Hommes Illustres d'Italie*, tom. i. p. 187.

METASTASIS, in *Medicine*, a transposition or settlement of some humour or disease in some other part; and sometimes it signifies such an alteration of a disease as is succeeded by a solution.

METATARSUS (μετα, *beyond*, and ταρσος, *the tarsus*), in anatomy, that part of the human skeleton containing the middle of the foot. See ANATOMY *Index*.

METATHESIS, in *Grammar*, a species of the metaplasmus; being a figure whereby the letters or syllables of a word are transposed, or shifted out of their usual situations, as *pistris* for *pristis*, *Lybia* for *Libya*, &c.

This word is, by physicians, used with respect to morbific causes, which when they cannot be evacuated, are removed to places where they are less injurious.

METELIN, the modern name of the island of Lesbos. See LESBOS and MITYLENE.

In the Irish Philosophical Transactions for 1789, we have a description of this island by the earl of Charlemont, in which he speaks with raptures of its beauties. "The mountains, whose rugged tops exhibit a pleasing interspersion of rocks and fine groves, have their green sides, for many miles along the coast, covered with olives, whose less agreeable verdure is corrected, embellished, and brightened by a lively mixture of bays and laurels aspiring to the height of forest trees, of myrtles and pomegranates, of arbutes rich at once in blossom and in berry, of mulberries growing wild and laden with fruit, &c. Winter is here unknown, the verdure is perpetual, and the frequency of evergreens gives to December the colour of June. The parching heat of summer is never felt; the thick shade of trees, and thousands of crystal springs which everywhere arise and form themselves into unnumbered rivulets, joined to the refreshing sea breeze, the constant corrective and companion of noontide heat, qualify the burning air, and render the year a never-ending May. The houses are constructed in such a manner as to have the best view of these natural beauties. Each is a square tower neatly built of hewn stone, so high as to overtop the trees, and to command a view of the sea and neighbouring islands. The lower stories are granaries and storehouses; and the habitable apartments are all at the top, to which you ascend by a stone stair, built for the most part on the outside, and surrounding the tower; so that from the apartment the trees are overlooked, and the whole country is seen; while the habitations themselves, which are very numerous, peering above the groves, add life and variety to the enchanting prospect, and give an air of human population to these woodlands, which might otherwise be supposed the region of Dryads, of Naiads, and of Satyrs."

The most remarkable thing, however, in this island is a custom by which the women have here openly usurped those rights of sovereignty which in other countries

countries are supposed to belong essentially to the men. "Contrary (says his lordship) to the usage of all other countries, the eldest daughter here inherits; and the sons, like daughters everywhere else, are portioned off with small dowers, or, which is still worse, turned out pennyless to seek their fortune. If a man have two daughters, the eldest, at her marriage, is entitled to all her mother's possessions, which are by far the greater part of the family estate, as the mother, keeping up her prerogative, never parts with the power over any portion of what she has brought into the family, until she is forced into it by the marriage of her daughter; and the father also is compelled to ruin himself by adding whatever he may have scraped together by his industry. The second daughter inherits nothing, and is condemned to perpetual celibacy. She is styled a *calogria*, which signifies properly a religious woman or nun, and is in effect a menial servant to her sister, being employed by her in any office she may think fit to impose, frequently serving her as waitingmaid, as cook, and often in employments still more degrading. She wears a habit peculiar to her situation, which she can never change; a sort of monastic dress, coarse, and of a dark brown. One advantage, however, she enjoys over her sister, that whereas the elder, before marriage, is never allowed to go abroad, or to see any man, her nearest relations only excepted, the calogria, except when employed in domestic toil, is in this respect at perfect liberty. But when the sister is married, the situation of the poor calogria becomes desperate indeed, and is rendered still more humiliating by the comparison between her condition and that of her happy mistress. The married sister enjoys every sort of liberty; the whole family fortune is hers, and she spends it as she pleases; her husband is her obsequious servant, her father and mother are dependent upon her, she dresses in a most magnificent manner, covered all over, according to the fashion of the island, with pearls and with pieces of gold, which are commonly sequins; thus continually carrying about her the enviable marks of affluence and superiority, while the wretched calogria follows her as a servant, arrayed in simple homespun brown, and without the most distant hope of ever changing her condition. Such a disparity may seem intolerable, but what will not custom reconcile? Neither are the misfortunes of the family yet at an end. The father and mother, with what little is left them, contrive by their industry to accumulate a second little fortune; and this, if they should have a third daughter, they are obliged to give to her upon her marriage; and the fourth, if there should be one, becomes her calogria, and so on through all the daughters alternately. Whenever the daughter is marriageable, she can by custom compel the father to procure her a husband; and the mother, such is the power of habit, is foolish enough to join her in teasing him into an immediate compliance, though its consequences must be equally fatal and ruinous to both of them. From hence it happens, that nothing is more common than to see the old father and mother reduced to the utmost indigence, and even begging about the streets, while their unnatural daughters are in affluence; and we ourselves have frequently been shown the eldest daughter parading it through the town in the greatest splendour, while her mother and sister followed her as servants, and made a melancholy part of her attendant train.

"The sons, as soon as they are of an age to gain a livelihood, are turned out of the family, sometimes with a small present or portion, but more frequently without any thing to support them; and thus reduced, they either endeavour to live by their labour, or, which is more usual, go on board some trading vessel as sailors or as servants, remaining abroad till they have got together some competency, and then return home to marry and to be henpecked. Some few there are who, taking advantage of the Turkish law, break through this whimsical custom, who marry their calogrias, and retain to themselves a competent provision: but these are accounted men of a singular and even criminal disposition, and are hated and despised as conformists to Turkish manners, and deserters of their native customs; so that we may suppose they are few indeed who have the boldness to depart from the manners of their country to adopt the customs of their detested masters, and to brave the contempt, the derision, and the hatred, of their neighbours and fellow-citizens.

"Of all these extraordinary particulars I was informed by the French consul, a man of sense and of indisputable veracity, who had resided in this island for several years, and who solemnly assured me that every circumstance was true: but indeed our own observation left us without the least room for doubt, and the singular appearance and deportment of the ladies fully evinced the truth of our friend's relation. In walking through the town, it is easy to perceive, from the whimsical manners of the female passengers, that the women, according to the vulgar phrase, *wear the breeches*. They frequently stopped us in the streets, examined our dress, interrogated us with a bold and manly air, laughed at our foreign garb and appearance; and showed so little attention to that decent modesty which is or ought to be the true characteristic of the sex, that there is every reason to suppose they would, in spite of their haughtiness, be the kindest ladies upon earth, if they were not strictly watched by the Turks, who are here very numerous, and would be ready to punish any transgression of their ungallant laws with arbitrary fines. But nature and native manners will often baffle the efforts even of tyranny. In all their customs these manly ladies seem to have changed sexes with the men. The woman rides astride, the man sits sideways upon the horse; nay, I have been assured that the husband's distinguishing appellation is his wife's family name. The women have town and country houses, in the management of which the husband never dares interfere. Their gardens, their servants, are all their own; and the husband, from every circumstance of his behaviour, appears to be no other than his wife's first domestic, perpetually bound to her service, and slave to her caprice. Hence it is that a tradition obtains in the country, that this island was formerly inhabited by Amazons; a tradition, however, founded upon no ancient history that I know of. Sappho indeed, the most renowned female that this island has ever produced, is said to have had manly inclinations; in which, as Lucian informs us, she did but conform with the singular manners of her countrywomen: but I do not find that the mode in which she

Metelin.

she chose to show these inclinations is imitated by the present female inhabitants, who seem perfectly content with the dear prerogative of absolute sway, without endeavouring in any other particular to change the course of nature; yet will this circumstance serve to show, that the women of Lesbos had always something peculiar, and even peculiarly masculine, in their manners and propensities. But be this as it may, it is certain that no country whatsoever can afford a more perfect idea of an Amazonian commonwealth, or better serve to render probable those ancient relations which our manners would induce us to esteem incredible, than this island of Metelin. These lordly ladies are for the most part very handsome in spite of their dress, which is singular and disadvantageous. Down to the girdle, which as in the old Grecian garb is raised far above what we usually call the waist, they wear nothing but a shift of thin and transparent gauze, red, green, or brown, through which every thing is visible, their breasts only excepted, which they cover with a sort of handkerchief; and this, as we are informed, the Turks have obliged them to wear, while they look upon it as an encumbrance, and as no inconsiderable portion of Turkish tyranny. Long sleeves of the same thin material perfectly show their arms even to the shoulder. Their principal ornaments are chains of pearl, to which they hang small pieces of gold coin. Their eyes are large and fine; and the nose, which we term Grecian, usually prevails among them, as it does indeed among the women of all these islands. Their complexions are naturally fine; but they spoil them by paint, of which they make abundant use; and they disfigure their pretty faces by shaving the hinder part of the eyebrow, and replacing it with a straight line of hair neatly applied with some sort of gum, the brow being thus continued in a straight and narrow line till it joins the hair on each side of their face. They are well made, of the middle size, and for the most part plump; but they are distinguished by nothing so much and so universally as by a haughty, disdainful, and supercilious air, with which they seem to look down upon all mankind as creatures of an inferior nature, born for their service, and doomed to be their slaves; neither does this peculiarity of countenance in any degree diminish their natural beauty, but rather adds to it that sort of bewitching attraction which the French call *piquant*."

His lordship has been at great pains to investigate the origin of such a singular custom; but is unable to find any other example in history than that of the Lycians, who called themselves by the names of their mothers, and not of their fathers. When asked by their neighbours who they were? they described themselves by their maternal genealogy. If a gentlewoman should marry a slave, the children by that marriage were accounted noble; but should the first man among them marry a foreign woman, the children would be accounted ignoble. This custom is mentioned by several ancient authors. A difficulty of no little magnitude occurs, however, in accounting for the derivation of the inhabitants of Lesbos from the Lycians. This is solved in the following manner: In times of the most remote antiquity, the island of Lesbos was peopled by the Pelasgi, who, under their leader Xanthus, the son of Trioppas king of Argos, first inhabited Lesbos: previous to that time they had dwelt in a certain part of Lycia which they had conquered; and in this country we may suppose they had learned the custom in question.

Metellus || Metempsychosis.

METELLUS, the surname of the family of the Cæcilii at Rome, the most known of whom were ——A general who defeated the Achæans, took Thebes and invaded Macedonia, &c.—Q. Cæcilius, who rendered himself illustrious by his successes against Jugurtha the Numidian king, from which he was surnamed Numidicus. Another who saved from the flames the palladium, when Vesta's temple was on fire. He was then high priest. He lost his sight and one of his arms in the action; and the senate, to reward his zeal and piety, permitted him always to be drawn to the senate house in a chariot, an honour which no one had ever before enjoyed. He also gained a great victory over the Carthaginians, &c.—Q. Cæcilius Celer, another who distinguished himself by his spirited exertions against Catiline. He married the sister of Clodius, who disgraced him by her incontinence and lasciviousness. He died 57 years before Christ. He was greatly lamented by Cicero, who shed tears at the loss of one of his most faithful and valuable friends. L. Cæcilius, a tribune in the civil wars of J. Cæsar and Pompey. He favoured the cause of Pompey, and opposed Cæsar when he entered Rome with a victorious army. He refused to open the gates of Saturn's temple, in which were deposited great treasures; upon which they were broke open by Cæsar, and Metellus retired when threatened with death. Q. Cæcilius, a warlike general who conquered Crete and Macedonia, and was surnamed *Macedonicus*. He had four sons, of whom three were consuls, and the other obtained a triumph, all during their father's lifetime. A general of the Roman armies against the Sicilians and Carthaginians. Before he marched, he offered sacrifices to all the gods except Vesta; for which neglect the goddess was so incensed, that she demanded the blood of his daughter Metella. When Metella was going to be immolated, the goddess placed a heifer in her place, and carried her to a temple at Lanuvium, of which she became the priestess. Another surnamed *Dalmaticus* from his conquest over Dalmatia, A. U. C. 634.—Cimber, one of the conspirators against J. Cæsar. It was he who gave the signal to attack and murder the dictator in the senate house. —Pius, a general in Spain against Sertorius, on whose head he set a price of 100 talents and 20,000 acres of land.

METEMPSYCHOSIS, (formed of μετα, "beyond," and εμψυχω, "I animate or enliven"), in the ancient philosophy, the passage or transmigration of the soul of a man, after death, into the body of some other animal.

Pythagoras and his followers held, that after death men's souls passed into other bodies, of this or that kind, according to the manner of life they had led. If they had been vicious, they were imprisoned in the bodies of miserable beasts, there to do penance for several ages: at the expiration whereof, they returned afresh to animate men. But, if they lived virtuously, some happier brute, or even a human creature, was to be their lot.

What led Pythagoras into this opinion was, the persuasion

persuasion he had that the soul was not of a perishable nature: whence he concluded that it must remove into some other body upon its abandoning this. Lucan treats this doctrine as a kind of officious lie, contrived to mitigate the apprehension of death, by persuading men that they only changed their lodging, and only ceased to live to begin a new life.

Reuchlin denies this doctrine; and maintains that the metempsychosis of Pythagoras implied nothing more than a similitude of manners, desires, and studies, formerly existing in some person deceased, and now revived in another alive. Thus when it was said that Euphorbus was revived in Pythagoras, no more was meant than that the martial virtue which had shone in Euphorbus at the time of the Trojan war, was now, in some measure, revived in Pythagoras, by reason of the great respect he bore the *athletæ*. For those people wondering how a philosopher should be so much taken with men of the sword, he palliated the matter, by saying, that the soul of Euphorbus, i. e. his genius, disposition, and inclinations, were revived in him. And this gave occasion to the report, that Euphorbus's soul, who perished in the Trojan war, had transmigrated into Pythagoras.

Ficinus asserts, that what Plato speaks of the migration of a human soul into a brute, is intended allegorically, and is to be understood only of the manners, affections, and habits, degenerated into a beastly nature by vice. Serranus, though he allows some force to this interpretation, yet inclines rather to understand the metempsychosis of a resurrection.

Pythagoras is said to have borrowed the notion of a metempsychosis from the Egyptians; others say, from the ancient Brachmans. It is still retained among the Banians and other idolaters of India and China; and makes the principal foundation of their religion. So extremely are they bigotted to it, that they not only forbear eating any thing that has life, but many of them even refuse to defend themselves from wild beasts. They burn no wood, lest some little animalcule should be in it: and are so very charitable, that they will redeem from the hands of strangers any animals that they find ready to be killed. See PYTHAGOREANS.

METEMPTOSIS (from μετα, *post*, and πιπτω, *cado*, "I fall,") a term in chronology, expressing the solar equation, necessary to prevent the new moon from happening a day too late. By which it stands contradistinguished from *proemptosis*, which signifies the lunar equation, necessary to prevent the new moon from happening a day too soon.

The new moons running a little backwards, that is, coming a day too soon at the end of 312 years and a half; by the proemptosis, a day is added every 300 years, and another every 2400 years: on the other hand, by the metemptosis, a bissextile is suppressed each 134 years; that is, three times in 400 years. These alterations are never made but at the end of each century; that period being very remarkable, and rendering the practice of the calendar easy.

There are three rules for making this addition or suppression of the bissextile day, and, by consequence, for changing the index of the epacts. 1. When there is a metemptosis without a proemptosis, the next following or lower index must be taken. 2. When there is a proemptosis without a metemptosis, the next preceding or superior index is to be taken. 3. When there are both a metemptosis and a proemptosis, or when there is neither the one nor the other, the same index is preserved. Thus, in 1600, we had D: in 1700, by reason of the metemptosis, C was taken: in 1800, there was both a proemptosis, and a metemptosis; so the same index was retained. In 1900, there will be a metemptosis again, when B will be taken: which will be preserved in 2000, because there will then be neither the one nor the other. This is as far as we need compute for it: But Clavius has calculated a cycle of 301,800 years; at the end of which period, the same indices return in the same order. See EPACT.

METEOR, (by the Greeks called μετεωρα, q. d. *sublima* or "high raised;" by the Latins *impressiones*, as making signs or impressions in the air), commonly denotes any bodies in the air that are of a transitory nature. Hence it is extended to the phenomena of hail, rain, snow, thunder, &c.; but is most commonly confined to those unusual and fiery appearances named *falling stars*, *ignes fatui*, *auroræ boreales*, &c. See METEOROLOGY.

METEOROLITE. This term is derived from the Greek μετεωρα, a *meteor*, and λιθος, a *stone;* and denotes a stony substance, exhibiting peculiar characters, and whose descent to the earth is usually accompanied by the appearance and explosion of a fire-ball.

Luminous meteors have, in all ages, been observed in the atmosphere. It is also well known that their disappearance has frequently been attended with a loud noise; but that they should moreover terminate in the fall of one or more solid bodies to the earth's surface, is a position so repugnant to our ordinary conceptions of the tenor of physical events, that we cannot admit it as a fact on slight or scanty evidence. With due deference, however, to some philosophers of name, we are not prepared to assert, that it implies impossibility. For who has explored the higher regions of the atmosphere? or who knows what may take place beyond its precincts? If a solid result from the combination of two aeriform substances, as muriatic acid and ammoniacal gases; if oxygen, the properties of which are most familiar to us in the state of gas, can undergo fixation, and if fluids can pass into crystalline forms, is it too bold to presume, that the same, or similar processes, effected in the grand laboratory of the atmosphere, may be within the range of possible occurrences? At all events, the same Being who called into existence those sublime and countless masses of matter which revolve in space, may, to serve purposes unknown to us, create bodies of dimensions infinitely smaller, and destined to impinge on some planetary orb. The reasoning of an angel may not convince us, that a part is greater than the whole, or that the value of two and two is equivalent to six; but a very ordinary logician may prove to our satisfaction, that the contact of particles of matter in portions of space which lie beyond our globe, is no chimerical supposition. Every thing around us proclaims, that matter is subject to incessant change. New forms and new modifications are ever springing into being: and can we doubt, that the same particles, as they may happen to be affected or influenced by various circumstances, may exist in the state of gas, of aqueous vapour, or of a concrete mass?

Again, it surely will not be seriously maintained, that, from the rarity of a phenomenon, we are warranted to infer its non-existence. The appearance of a comet is a rare, but not a fictitious, occurrence. Nay, we may safely advance a step farther, and assert, without fear of confutation, that the existence of a phenomenon, if otherwise well attested, cannot be disproved by our inability to explain it. How multiplied, in fact, are the subjects, even of our daily and hourly observation, which we cannot satisfactorily expound? We cannot say why a small seed should gradually unfold into a large tree, why flame should produce heat, why the hand should act in immediate subserviency to the will, or why a contusion of the brain should induce stupor, alienation of mind, or death. It is one thing to prove a fact, and it is another to account for it.

From these premises it follows in course, that we are not entitled to reject the existence of meteoric stones, provided it be established by valid testimony. Should the historical evidence, on a fair and dispassionate review, be deemed conclusive, we may afterwards examine the theories which have been proposed for the solution of the appearance.

From the Scriptures of the Old Testament we are not aware that any passage can be cited in direct corroboration of the descent of stones from the atmosphere. The ingenious and fanciful Mr Edward King, indeed, in his "Remarks concerning stones said to have fallen from the clouds, both in these days, and in ancient times," adverts to the 13th verse of the 18th Psalm.—"The Lord also thundered out of heaven, and the Highest gave his thunder: hail-stones and *coals of fire*." This last expression has, no doubt, been conjectured to denote real hard bodies, in a state of ignition; and the term ανθρακες, employed by the cautious Seventy, rather favours such an interpretation. The same expression, however, occurs in the preceding verse, without admitting this interpretation; and the phrase seems to be only a figurative mode of describing lightning. In the sober latitudes of the north, and even in colloquial language, we talk of *balls of fire* and *thunderbolts*, without any reference to solid matter. Mr King likewise quotes the 11th verse of the 10th chapter of Joshua.—"And it came to pass, as they fled from before Israel, and were in the going down to Beth-horon, that the Lord cast down *great stones* from heaven upon them unto Azekah, and they died: there were more which died with hail-stones, than they whom the children of Israel slew with the sword." Here, the expression, *great stones* is less equivocal than *coals of fire*; yet the context hardly allows us to doubt, that the great stones were really hail-stones, or rather, perhaps, lumps of ice, consolidated in the atmosphere, such as occasionally fall in hot countries, and such as alarmed the whole of Paris and its neighbourhood in 1788. At any rate, the slaughter of the Canaanites is represented as resulting from the special interposition of divine power; and the consideration of miracles is irrelevant to our present purpose.

If from sacred, we turn to the early period of profane history, we shall find the annals of public events very copiously interspersed with notices of strange appearances, many of which may be safely ascribed to the ascendency which superstition long obtained over the human mind. The scepticism of the learned is, however, sometimes not less injudicious and indiscriminate than the credulity of the savage; and he who should resolve every extraordinary event, which is recorded by the writers of Greece and Rome, into a "cunningly devised fable," would not be less reprehensible for want of candour, than the untutored rustic, who yields his assent to every alleged miracle, is to be taxed with want of discernment.

Although these general positions can scarcely admit of dispute, it becomes extremely difficult, after a lapse of many ages, and in the collation of marvellous records, to separate truth from falsehood. In our attempts to prosecute this analytical process, we may sometimes advance a certain length with perfect security, without being able to trace uniformly the precise lines of demarcation. Thus, in regard to the topic of our present discussion, we know, that in various periods of the world the vulgar have ascribed a celestial origin to stones of a peculiar configuration, as to certain modifications of pyrites, to belemnites, orthoceratites, &c. which the subsequent observations of naturalists have proved to be of mineral formation, and to the heads of arrows and sharpened flints, which have been fashioned by the hand of man, and which, accordingly we are authorized to exclude from the ex-terrestrial catalogue. But when substances dissimilar from these, and coinciding in any one character or circumstance with modern specimens of atmospheric stone, are reported by the ancients to have fallen from the clouds, the distance of ages and the lameness of the documents may powerfully affect our appreciation of the reputed evidence.

When, therefore, we shortly touch on a few of the many instances which might be quoted from the annals of antiquity, we mean not to vouch for the truth even of these particular instances; but merely to admit their probability, and the weight which the mention of them may be considered to add to that of subsequent and recent narrations.

Through the midst of fable which envelopes the history of the *bætuli*, we discern some characters which correspond with those of meteorolites. Thus, in the Λιθικα, a poem falsely ascribed to Orpheus, the σιδηριτης, which M. Falconet properly classes with the bætuli, is said to be *rough*, *heavy*, and *black*. Damascius, in an extract of his life of Isidorus, preserved by Photius, relates that the bætuli fell on Mount Libanus, in *a globe of fire*. A fragment of Sanchoniathon, preserved in Eusebius, (Præpar. Evangel. i. 10.), moreover informs us, that these stones were fabricated by the god *Uranus* (or *Heaven*), one of whose four sons was named *Bætul*. May not this mythological genealogy be regarded as merely emblematical of their descent from the upper regions of the atmosphere? In the same chapter we are told that Astarte found a *star* which had *fallen from heaven*, and honoured it with consecration in the city of Tyre. The stone denominated "the mother of the gods," if we can believe Appian, Herodian, and Marcellinus, *fell from heaven*. Aristodemus, cited by the Greek scholiast on Pindar, asserts that it *fell encircled by fire*, on a hill, at the feet of the Theban bard. It is said to have been of a *black* colour, and of an *irregular* shape. Herodian (lib. v.) expressly declares, that the Phœnicians had no statue of the sun, polished by the hand; but only a certain stone, circular below, and terminated

terminated acutely above, in the form of a cone, of a *black* colour, and that, according to report, it *fell from heaven*, and was regarded as the image of the sun.

Among various instances which might be selected from Livy, is that of a shower of stones on Mount Alba, in the reign of Tullus Hostilius, or about six hundred and fifty-two years before the birth of Christ. When the senate were told, that it had *rained stones*, they doubted the fact, and deputed commissioners to inquire into the particulars. They were then assured, that stones had really fallen, *haud aliter quam quum grandinem venti glomeratam in terras agunt*. On this occasion, the historian mentions, that similar events were celebrated by a festival of nine days. *Mansit solenne, ut quandocunque idem prodigium nuntiaretur, feriæ per novem dies agerentur*.

But one of the most remarkable cases which occurs in the records of antiquity, is that which is mentioned in the 58th chapter of the second book of Pliny's Natural History, of a large stone which fell near Ægospotamos, in Thrace, in the second year of the seventy-eighth Olympiad, or, according to our chronology, about four hundred and sixty-seven years before the Christian era. Pliny assures us, that this extraordinary mass was still shown in his day; and that it was as large as a cart, and of a *burnt colour*. The Greeks pretended that it had *fallen from the sun*, and that Anaxagoras had predicted the day of its arrival on the earth's surface. According to Plutarch, in the life of Lysander, the inhabitants of the Chersonesus held the Thracian stone in great veneration, and exhibited it as a public show. His account of its first appearance is chiefly extracted from the relation of Daimachus of Platææ, and may be thus translated. "During seventy-five successive days before the stone fell, a large fiery body, like a cloud of flame, was observed in the heavens, not fixed to one point, but wandering about with a broken irregular motion. By its violent agitation, several fiery fragments were forced from it, impelled in various directions, and darted with the velocity and brightness of so many shooting stars. After this body had fallen on the Chersonesus, and the people had assembled to examine it, they could find no inflammable matter, nor the slightest trace of combustion, but a real stone, which, though large, by no means corresponded to the dimension of the flaming globe which they had seen in the sky, but seemed to be only a piece detached from it." Daimachus, it is true, may, on this occasion, have given way to his reputed love of the marvellous; and we can easily believe that the *seventy-five continuous days* are either an error of the copyist, or an original exaggeration; yet, from the marked coincidence of some of the circumstances with those more fully detailed in the sequel, there arises the presumption that a meteorolite really fell at the place and period above assigned.

From this period till near the close of the fifteenth century, any historical notices which we have been enabled to collect, are so vague and scanty, that, in this abridged view of the subject, we may pass them over in silence.

Professor Bantenschoen, of the central school of Colmar, first directed the attention of naturalists to some of the old chronicles, which commemorate with much *naivete*, and in the true spirit of the times, the fall of the celebrated stone of Ensisheim. The following account accompanied this very singular mass, when it was suspended in the church.

"In the year of the Lord 1492, on Wednesday, which was Martinmas eve, the 7th of November, there happened a singular miracle: for, between eleven o'clock and noon, there was a loud peal of thunder, and a prolonged confused noise, which was heard to a great distance, and a stone fell from the air, in the jurisdiction of Ensisheim, which weighed 260 pounds, and the confused noise was, moreover, much louder than here. There a child saw it strike on a field, situated in the upper jurisdiction, towards the Rhine and Inn, near the district of Gisgard, which was sown with wheat, and did it no harm, except that it made a hole there: and then they conveyed it from that spot; and many pieces were broken from it, which the landvogt forbade. They, therefore, caused it to be placed in the church, with the intention of suspending it as a miracle; and many people came hither to see this stone. So there were remarkable conversations about this stone: but the learned said, that they knew not what it was; for it was beyond the ordinary course of nature, that such a large mass should smite the earth from the height of the air; but that it was really a miracle of God; for, before that time, never any thing was heard like it, nor seen, nor described. When the people found that stone, it had entered into the earth, to the depth of a man's stature, which every body explained to be the will of God, that it should be found, and the noise of it was heard at Lucerne, at Villing, and in many other places, so loud, that it was believed that houses had been overturned: And as the king (Maximilian) was here, the Monday after St Catherine's day, of the same year, his royal excellence ordered the stone which had fallen to be brought to the castle, and after having conversed a long time about it with the noblemen, he said the people of Ensisheim should take it, and order it to be hung up in the church, and not allow any body to take any thing from it. However, his excellency took two pieces of it, of which he kept one, and sent the other to the duke Sigismund of Austria: and they spoke a great deal about this stone, which they suspended in the choir, where it still is; and a great many people came to see it."

Trithemius, in his Hirsaugiensian Annals, employs language to this effect.—"In the same year, on the 7th day of November, in the village of Suntgaw, near the townlet of Ensisheim, not far from Basil, a city of Germany, a stone, called a thunder-stone, of a prodigious size, for we know from eye-witnesses that it weighed 255 pounds, fell from the heavens. Its fall was so violent, that it broke into two pieces. The most considerable is still exhibited at the door of the church of Ensisheim, suspended by an iron chain, as a proof of the fact which we have mentioned, and to preserve it in the public recollection."—We learn also from Paul Lang that there arose a furious storm on the 7th of November 1492, and that while the thunder roared, and the heavens appeared all on fire, a stone of enormous size fell near Ensisheim. Its form was that of the Greek delta, with a triangular point. They still show it at Ensisheim as an astonishing phenomenon."

It is worthy of observation, that these chroniclers lived at the period which they assign to the descent of the

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the stone; and that, though their names are hastening to oblivion, Trithemius yielded to few of his contemporaries in labour and learning; while Lang, a German Benedictine as he was, travelled in search of historical monuments, arraigned the license of the catholic clergy, and applauded the independence of Luther and Melancthon.

Of the Ensisheim stone, which has been transported to the national library at Colmar, and which, notwithstanding various *dilapidations*, stills weighs 150 pounds, some interesting specimens may now be seen in the cabinets of the curious. Robert Ferguson, Esq. younger of Raith, has, in the most polite and obliging manner, gratified us with the sight of a small fragment, which belongs to his valuable collection of minerals at Raith house in Fifeshire, Scotland.

We are fully aware, that M. Barthold has laboured to convince his readers (Journal de Physique, Ventose, year 8.) that the far-famed mass of Ensisheim is merely argillo-ferrugineous, of secondary formation, detached from an adjacent mountain, and conveyed to the spot on which it was found by some torrent or land-flood. In this opinion, we might partially acquiesce, did not the artlessness of contemporary and concurring records militate against it, and had not the more accurate analysis of Vauquelin detected the same constituent parts as in the other stony and metalline substances denominated meteoric. "It is certainly composed of silica," observes this celebrated chemist, "of magnesia, of iron, of nickel, of sulphur, and of a small quantity of lime.—Particular trials have convinced me of the presence of sulphur and nickel in the grains of malleable iron, and in the pyrites, though in different proportions. This stone, then, in every respect, resembles others which have fallen from the atmosphere."

In the Commentary of Surius, a Carthusian monk of Cologne, mention is made of a shower of large stones in Lombardy, in 1510. These stones were harder than flint, and smelled of sulphur. The heaviest weighed 120 pounds. The same event is more particularly related by Cardan, in his work intitled *de Rerum Varietate* (lib. xiv. c. 72.). According to this author, near the river Adda, not far from Milan, and at five oclock in the evening, about 1120 stones fell from the air, one of them weighing 120 pounds and another 60 pounds. Many were presented to the French governor, and his deputy. At three o'clock P. M. the sky appeared as if in a general blaze; and the passage, though somewhat ambiguous, would lead us to infer, that the meteor was visible for two hours. Like many of the learned and unlearned of his day, Cardan instantly connects the extraordinary appearance with the political transactions of his district.

We next pass to an interesting extract from the memoirs of the emperor Jehangire, written in Persian, by himself, and translated by Colonel Kirkpatrick.

"*A. H.* 1030, *or 16th year of the reign.*—The following is among the extraordinary occurrences of this period.

"Early on the 30th of Furverdeen of the present year (1620), and in the eastern quarter of the heavens, there arose in one of the villages of the purgunnah of Jalindher, such a great and tremendous noise, as had nearly, by its dreadful nature, deprived the inhabitants of the place of their senses. During this noise, a luminous body was observed to fall from above, on the earth, suggesting to the beholders the idea that the firmament was raining fire. In a short time, the noise having subsided, and the inhabitants having recovered from their alarm, a courier was dispatched to *Mahommed Syeed*, the aumul of the aforesaid purgunnah, to advertise him of this event. The aumil, instantly mounting his horse, proceeded to the spot. Here he perceived the earth, to the extent of a dozen of yards in length and breadth, to be burned to such a degree, that not the least trace of verdure, or a blade of grass remained; nor had the heat yet subsided entirely.

"*Mahommed Syeed* hereupon directed the aforesaid space of ground to be dug up; when the deeper it was dug, the greater was the heat of it found to be. At length a lump of iron made its appearance, the heat of which was so violent, that one might have supposed it to have been taken from a furnace. After some time it became cold: when the aumil conveyed it to his own habitation, from whence he afterwards dispatched it in a sealed bag to court.

"Here I had this substance weighed in my presence. Its weight was 160 tolahs (A). I committed it to a skilful artisan, with orders to make of it a sabre, a knife, and a dagger. The workman reported, that the substance was not malleable, but shivered into pieces under the hammer.

"Upon this I ordered it to be mixed with other iron. Conformably to my orders, three parts of the *iron of lightning* (B) were mixed with one part of common iron; and from the mixture were made two sabres, one knife, and one dagger."

Our limits will not permit us to give the whole of the extract, nor the remarks of the Right Hon. Charles Greville and Colonel Kirkpatrick, which were read before the Royal Society of London, on the 27th January, 1803. We feel, however, no hesitation in attaching to this document something very nearly approaching to direct evidence of the fact in question.

The celebrated Gassendi relates, that, on the 27th of November, 1627, about 10 o'clock A. M. during a very clear sky, he saw a flaming stone, of the apparent diameter of four feet, fall on Mount *Vaision*, an eminence situated between the small towns of Perne and Guillaumes, in Provence. This stone was surrounded by a luminous circle of different colours, nearly resembling the rainbow, and its fall was accompanied with a noise like the discharge of artillery. It weighed 59 pounds; and its specific gravity was to that of common marble as 14 to 11. It was of a dark metallic colour, and extremely hard. Though it was not subjected to chemical analysis, and is not now to be found, the circumstances which have been stated by the philosopher are sufficiently

(A) A tolah is about 180 grains, Troy weight.
(B) This expression is equivalent to our term *thunder-bolt*.

sufficiently minute to operate on the conviction of those who are willing to be convinced.

From a curious book printed at Paris in 1672, and now become very scarce, entitled *Conversations tirées de l'Académie de M. l'Abbe Bourdelot, contenant diverses recherches et observations physiques, par le Sieur Legallois*, we make the ensuing extract.

"A member presents a fragment of two stones which fell near Verona, one of which weighed 300, and the other 200 pounds. These stones," says he, "fell during the night, when the weather was perfectly mild and serene. They seemed to be all on fire, and came from above, but in a slanting direction, and with a tremendous noise. This prodigy terribly alarmed 300 or 400 eye-witnesses, who were at a loss what to think of it. These stones fell with such rapidity, that they formed a ditch, in which, after the noise had ceased, the spectators ventured to approach them, and examine them more closely. They then sent them to Verona, where they were deposited in the Academy, and that learned body sent fragments of them to different places." That which accompanied the above intimation was of a yellowish hue, very easily pulverised, and smelled of sulphur.—In the course of examining one of these stones, M. Laugier, professor of pharmacy at Paris, has recently detected the presence of chrome, by means of the caustic alkali.—The date of the Verona phenomenon, if we have been correctly informed, is 1663.

In the Bornian collection there is a substance which is designated *Ferrum retractorium, granulis nitentibus matrice virescenti immixtis* (*Ferrum virens Lin.*), *cujus fragmenta ab unius ad viginti usque librarum pondus, cortice nigro scoriacco circumdata, ad Plann, prope Tabor, circuli Bechinensis Bohemiæ, passim reperiuntur.* The following note is subjoined. (*Quæ fragmenta 3 Julii anni 1753, inter tonitrua, è cælo pluisse creduliores quidam asserunt*). The expression *crcduliores quidam*, it may be alleged, at once destroys the evidence of this memorandum. It deserves, however, to be noted, that, in regard to our present subject, what was formerly accounted the credulity of the vulgar, may now, on several occasions, be construed into probability, if not into matter of fact; and that Mr Greville has found the identical fragment to have the same composition with other meteoric stones. Hence, we are compelled either to admit its ex-terrestrial origin, or the existence of a substance, originally belonging to the earth, and yet agreeing in character with those deemed atmospheric. The former part of the alternative is perfectly consonant with well-authenticated facts; whereas of the latter, we are not warranted to pronounce, that a single case has hitherto been established to the satisfaction of any chemist or mineralogist.

But we have now to turn our attention to a report of M. de la Lande, inserted in the Historical Almanack of Bresse, for 1756.

In the month of September 1753, about one o'clock P. M. when the weather was very hot, and very serene, without the least appearance of a cloud, a very loud noise, like the discharge of two or three cannons, was heard within the circumference of six leagues, but was of very short duration. This noise was loudest in the neighbourhood of Pont-de-Vesle; and at Liponas, a village three leagues from the last-mentioned place, it was even accompanied with a hissing, like that of a cracker. On the same evening there were found at Liponas and at Pin, two blackish masses, of a form nearly circular, but very uneven, which had fallen on ploughed ground, and sunk, by their own weight, to half a foot below the surface. One of them weighed about twenty pounds; and a fragment of one of them weighing $11\frac{1}{2}$lb. was preserved in the cabinet of M. Varenne de Beost, at Dijon. The basis of these masses resembled a grayish whinstone, and was very refractory; and some ferrugineous particles were disseminated in grains, filaments, or minute masses, through the substance of the stone, especially in its fissures. This iron, when subjected to a red heat, became obedient to the magnet. The black coating on the surface, M. de la Lande ascribes to fusion, induced by violent heat. This gentleman's acknowledged respectability and accuracy of observation, combined with the circumstances which he has adduced, circumstances, too, which, if misstated, lay so open to public investigation, powerfully plead in favour of his testimony.

On the 15th of September 1760, according to the abbé Bachclay, about half past four o'clock P. M. there appeared near the chateau de Chevabrie, in the neighbourhood of Luce, a small town of the province of Maine, a stormy cloud, from which proceeded a loud peal of thunder, like the discharge of cannon, and followed by a noise which was mistaken by several people for the lowing of oxen. This sound was heard over a space of about two leagues and a half, but unaccompanied by any perceptible flame. The reapers in the parish of Perigué, about three leagues from Luce, on hearing the same noise, looked up, and saw an opake body, which described a curve, and fell on soft turf, on the high road from Mons, near which they were at work. They all quickly ran up to it, and found a sort of stone, nearly half of which was buried in the earth, and the whole so hot that it could not be touched. At first they ran away in a panic; but on returning to the spot some time after, they found the stone precisely in the same situation, and sufficiently cooled to admit of being handled, and narrowly examined. It weighed seven ounces and a half, and was of a triangular form, presenting, as it were, three rounded horns, one of which, at the moment of the fall, had entered into the ground, and was of a gray or ash colour, while the rest, which was exposed to the air, was very black. When the abbé presented this stone to the academy, that body appointed three of its number, namely, Messieurs Lavoisier, Fougeroux, and Cadet, to examine and analyse it. This task they performed with more care and accuracy than M. de la Lande had done on the preceding occasion; but their trial was confined to an integral part of the whole, considered as a homogeneous substance, in place of being repeated on each of the constituent parts. The substance was of a pale cinereous hue, speckled with an infinite number of small and shining metallic points, visible through a magnifying glass. That part of the outer surface which remained above ground was incrusted with a thin black coating, which seemed to have undergone fusion, and which gave a few sparks when struck with steel. The specific gravity of the mass was 3535.—Two other stones, nearly of the same characters, the one reported to have fallen at Aire, in Artois, and the

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the other in the Cotentin, in Normandy, were presented to the academy in the course of the same year by M. Gurson de Boyaval, honorary lieutenant-general of the bailliage of Aire, and the younger M. Morand. According to the academical report, these three stones, when compared, presented no difference to the eye, were of the same colour, and nearly of the same grain, exhibiting metallic and pyritous particles, and covered with a black and ferrugineous incrustation. Although the coincidence of facts and circumstances, in three places so remote from one another, did not convince the academy that these stones had been conveyed to the earth by lightning, yet it induced them to invite naturalists to prosecute the examination of the subject.

On the 20th of November 1768, a stone fell at Mauerkircken near the Inn, in Bavaria, that weighed 38lb. was of a triangular form, and only eight inches in thickness. Its fall was accompanied by a hissing noise, and great darkness in the atmosphere. This meteorolite penetrated two feet and a half into the soil. Part of it is in the cabinet of the right honourable Charles Greville, which is now in the British Museum; and a fragment may be seen in Mr Ferguson's collection quoted above.

The next remarkable case on record occurred on the 20th of August 1789, at Barbotan, near Roquefort, in the *Landes* of Bourdeaux, and is thus related by Citizen Lomet, who was known to several members of the Institute, and happened to be at Agen when the meteor appeared.

"It was a very bright fire-ball, luminous as the sun, of the size of an ordinary balloon, and, after inspiring the inhabitants with consternation, burst and disappeared. A few days after, some peasants brought stones, which they said fell from the meteor; but the philosophers to whom they offered them laughed at their assertions as fabulous. The peasants would have now more reason to laugh at the philosophers."—One of these stones broke through the roof of a cottage, and killed a herdsman and some cattle. Vauquelin, who received a *proces-verbal* of the circumstances, also examined one of the specimens. The fragment procured by Mr Ferguson has visibly all the characters of a genuine meteorolite.

A much more remarkable phenomenon, however, of the same description, occurred near Agen, on the 24th of July 1790. An inhabitant of St Severe communicates the following particulars to M. Darcet the chemist, who was then resident at Paris.

"Our towns-people were yesterday very much alarmed. About a quarter past nine o'clock, in the evening, there suddenly appeared in the air a fire-ball, dragging a long train, which diffused a very vivid light over the horizon. This meteor soon disappeared, and seemed to fall at one hundred paces from us. It was quickly followed by an explosion louder than that of a cannon or of thunder. Every body dreaded being buried under the ruins of his house, which seemed to give way from the concussion. The same phenomenon was seen, and the report heard, in the neighbouring towns, as Mont de Marsan, Tartas, and Dax. The weather in other respects was very calm, without a breath of wind or a cloud, and the moon shone in all her brightness."

M. Darcet's brother, a clergyman in that part of the country, sent him a small stone, which was picked up on the morning after the explosion, and the history of which he was scrupulously anxious to investigate. Being satisfied with respect to all the particulars, he at length dispatched it to Paris, accompanied with some curious remarks. "When these stones fell," says he, "they had not their present degree of hardness. Some of them fell on straw, bits of which stuck to the stones, and incorporated with them. I have seen one in this predicament. It is at present at La Bastide; but I cannot persuade the owner to part with it***. Those which fell on the houses produced a noise, not like that of stones, but rather of a substance which had not yet acquired compactness."

We subjoin the *proces-verbal*—a simple but authentic document.

"In the year one thousand seven hundred and ninety, and the 30th day of the month of August, we, the Sieur Jean Duby, mayor, and Louis Maullon, procurator of the commune of the municipality of La Grange de Juillac, and Jean Darmite, resident in the parish of La Grange de Juillac, certify in truth and verity, that, on Saturday the 24th of July last, between nine and ten o'clock in the evening, there passed a great fire, and after it we heard in the air a very loud and extraordinary noise; and, about two minutes after, there fell stones from heaven, but fortunately there fell only a very few, and they fell about ten paces from one another in some places, and in others nearer, and finally, in some other places, farther, and falling, most of them, of the weight of about half a quarter of a pound each; some of about half a pound, like that found in our parish of La Grange; and on the borders of the parish of Creon, they were found of a pound weight; and in falling they seemed not to be inflamed, but very hard and black without, and within of the colour of steel; and, thank God, they occasioned no harm to the people, nor the trees, but only to some trees which were broken on the houses; and most of them fell gently, and others fell quickly, with a hissing noise; and some were found which had entered into the earth, but very few. In witness whereof we have written and signed these presents. (Signed) Duby, Mayor—Darmite."

Monsieur Baudin mentions, that, as M. Carris of Barbotan and he were walking in the court of the castle of Mormes about half past nine o'clock, in the evening of the 24th of July 1790, when the air was perfectly calm, and the sky cloudless, they found themselves suddenly surrounded by a pale clear light, which obscured that of the moon, though the latter was nearly full. On looking up, they observed, almost in their zenith, a fire-ball of a larger apparent diameter than that of the moon, dragging a tail, which seemed to be five or six times longer than the diameter of its body, and which gradually tapered to a point, the latter approaching to blood-red, though the rest of the meteor was of a pale white. This luminous body proceeded with great velocity from south to north, and in two seconds split into portions of considerable size, like the fragments of a bursting bomb. These fragments became extinguished in the air, and some of them, as they fell, assumed that deep red colour, which had been observed at the point of the tail. Two or three minutes after M. Baudin and his friend heard a dreadful explosion, like the simultaneous firing of several pieces of ordnance; but they were not sensible of any tremulous motion under their feet, though the concussion

sion of the atmosphere shook the windows in their frames, and threw down kitchen utensils from their shelves. When these gentlemen removed to the garden, the noise still continued, and seemed to be directly over their heads. Some time after it had ceased, they heard a hollow sound rolling, in echoes, for fifty miles, along the chain of the Pyrenees, and at the end of about four minutes gradually dying away in distance. At the same time, a strong sulphureous odour was diffused in the atmosphere. The interval which occurred between the disruption of the meteor, and the loud report, induced M. Baudin to conjecture, that this fireball must have been at least eight miles from the earth's surface, and that it fell about four miles from Mormes. "The latter part of my conjecture, says he, was soon confirmed by an account which we received of a great many stones having fallen from the atmosphere at Juillac and in the neighbourhood of Barbotan." It appears, indeed, from the concurring testimony of intelligent persons worthy of credit, that the meteor really exploded at a little distance from Juillac, and that its fragments were found lying in an almost circular space, of nearly two miles in diameter. Some of them weighed eighteen or twenty, and a few, it is alleged, even fifty pounds. M. de Carris procured one of 18 lbs. which he transmitted to the Parisian Academy of Sciences. That examined by M. Baudin was small, but heavy in proportion to its size, black on the outside, grayish within, and interspersed with many minute, shining, metallic particles. These last circumstances perfectly accord with the fragment of a Barbotan stone preserved in Mr Ferguson's collection.

In one of his letters to Professor St Amand, M. Goyon d'Arzas remarks, that these stones, though generally smooth on the outside, presented some longitudinal cracks, or fissures, while their interior parts exhibited symptoms of metallic veins, especially of a ferrugineous complexion. When yet red hot, and scattered in various directions, they formed that magnificent fire-work, that shower of flame, which enlightened the horizon over a large tract of country; for this extraordinary meteor was seen at Bayonne, Auch, Pau, Tarbes, and even at Bourdeaux and Toulouse. At the last-mentioned place it excited little attention, on account of its great distance, and its appearing only a little brighter than a shooting star. It, moreover, deserves to be noted, that the meteorolites in question were found on a bare moor, of an extremely thin soil, on which no such stones, or indeed stones of any description, had been observed in the memory of man. They who are solicitous of additional information on this part of our subject, may consult N°. 23 and 24 of the *Journal des Sciences Utiles* of Montpelier, for 1790, and the *Decade Philosophique* for February 1796.

When all the circumstances of the case are duly considered, we need not be surprised, that they should produce conviction on the minds of many men of science, who, till then, possessed "an evil heart of unbelief." M. de St Amand ingenuously confessed to M. Pictet of Geneva, that he had treated this novel topic with unmerited contempt, and that the evidence deduced from the similar characters of the stones should not be rashly rejected. The learned and the unlearned of the district in which the phenomenon is stated to have occurred, attest its existence; the professor of natural history in the central school of Agen renounces his former scepticism; Vauquelin analyses a specimen, and finds it to contain the same chemical substances as other meteorolites, and in nearly the same proportions; and shall we be so unreasonable as to withhold our assent, merely because we have not *ocular demonstration* of the alleged particulars?

Our chronological series of cases has now brought us to the fall of several meteorolites near Sienna, the particulars of which, as reported by the late earl of Bristol and Sir William Hamilton, are recorded in the first part of the Philosophical Transactions for 1795 (page 103). Mr King, likewise in the tract which we have already quoted, communicates some interesting circumstances relative to this phenomenon, chiefly extracted from an account of it published by Professor Soldani. While we refer our readers to these details, we cannot omit mentioning that, in regard to aspect and composition, the Sienna stones are perfectly analogous to others already noticed, and very different from any that occur in Tuscany. As the meteor from which they were discharged appeared on the morning after a violent eruption of Vesuvius, they were at first supposed to be volcanic, till cool reflection and examination betrayed the extravagance of such a hypothesis. The precise number of stones which were collected on this occasion is not specified, but many of them were small, weighing from a quarter of an ounce to two ounces. A pretty entire specimen occurs in Mr Ferguson's collection.—The date of the Sienna meteor is the 16th of June, 1794.

On the 13th of December of the following year, about three o'clock in the afternoon, another of these singular stones, weighing 56 pounds, fell near the country house of Captain Topham, in Yorkshire. The captain's report, which is inserted in the Gentleman's Magazine for 1796, is distinct and satisfactory; while the chemical examination of the mass, detailed in Mr Howard's paper, in the Philosophical Transactions for 1802, affords a still more decisive proof of its atmospheric origin. M. de Drée, also found it to correspond exactly in aspect and character, with fragments of meteor stones from Benares and Ville-franche. The original mass is in the possession of Mr Sowerby author of English Botany, &c. It is larger than a man's head.

Mr Southey, in his letters from Spain and Portugal, transcribes the authenticated relation of another instance of the descent of a stone from the clouds on the 19th of February 1796. But we pass to some of the most important details relative to the stone which is affirmed to have fallen near Ville-franche, in the department of the Rhone, on the 12th of March, 1798. When it was transmitted to Professor Sage, member of the National Institute, he considered it at first, as only a pyritous and magnetical ore of iron, although it bore no resemblance to any known species of ore of that metal, since it contained nickel, silica, magnesia, and native iron, which shone like steel when polished. "It is of an ash gray colour, says M. Sage, granulated and speckled with gray, shining, and pyritous metallic points. One of its surfaces is covered with a dingy black enamel, about the third of a line in thickness. This stone acts very powerfully on the magnetic needle. When the senator Chasset transmitted it to me, it was

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was accompanied with an historical notice of similar import with that of M. Delievre, of Ville-franche, who saw and described the phenomenon on the spot."

At six o'clock in the evening, a round body, which diffused the most vivid light, was observed in the vicinity of Ville-franche, moving westward, and producing a hissing, like that of a bomb which traverses the air. This luminous body, which was seen at the same time at Lyons and on Mont-Cenis, marked its path by a red track of fire, and exploded, about 200 toises from the earth with a tremendous report and concussion. One of the flaming fragments fell on the vineyard of Peter Crepier, an inhabitant of Sales. On the spot where this portion of the meteor was seen to fall, and in a fresh opening of about 20 inches in depth, and 18 in width, was found a black mass, 15 inches in diameter, and rounded on one side.

An account of the same meteor was published in the Journal de Physique, for Floreal, year 11, by M. de Drée. From his minute and deliberate investigation, it appears that the fire-ball had scarcely fixed the attention of the inhabitants of Sales and the adjacent villages, when its rapid approach, accompanied by a terrible whizzing noise, like that of an irregular hollow body, traversing the air with unusual velocity, inspired the whole commune with alarm, especially when they observed it passing over their heads, at an inconsiderable elevation. It left behind a long train of light, and emitted, with an almost unceasing craekling, small vivid flames, like little stars. Its fall was remarked, at the distance of only 50 paces, by three labourers, one of whom, named Montillard, let fall his coat and bundle of sticks that he might run the faster, while the other two, Chardon and Lapoces, fled with equal precipitation to Sales, where the alarm had become general.—These three witnesses attest the astonishing rapidity of the meteor's motion, and the hissing which proceeded from the spot where it fell. So terrified was Crepier at the explosion, that he locked himself up with his family, first in his cellar, and then in his private apartment, nor ventured abroad till next morning, when, in the company of M. Blandel, Chardon, Lapoccs, and many others, he repaired to the opening which had been made by the fire ball. At the bottom of this opening, which was 18 inches deep, including the entire thickness of the mould, they found a large black mass, of an irregularly ovoid form, having a fanciful resemblance to a calf's head. Though no longer hot, it smelled of gun-powder and was cracked in several places. When the observers broke it, and discovered nothing but stone, indifference succeeded to curiosity, and they coolly ascribed its appearance to causes more or less whimsical and supernatural.

The original weight of this stone was about twenty pounds. Its black vitrified surface gave fire with steel. Its interior was hard, earthy, ash-coloured, of a granular texture, presenting different substances scattered through it, namely, iron in grains, from the smallest size to a line or even more in diameter, somewhat malleable, but harder and whiter than forged iron; white pyrites, both lamellated and granular, and in colour approaching to nickel; some gray globules, which seemed to present the characters of trapp, and a very few and small particles of steatites, inclining to an olive hue. On account of its heterogeneous composition, its specific gravity could not be easily ascertained. One hundred parts of the mass gave, according to Vauquelin, 46 of silica, 38 oxide of iron, 15 magnesia, 2 nickel, and 2 lime. The excess of this result was ascribed to the absorption of oxygen by the native iron during the process. A small specimen of this mass belongs to Mr Ferguson's collection.

On the 19th of December 1798, about eight o'clock in the evening, the inhabitants of Benares and its neighbourhood observed in the heavens a very luminous meteor, in the form of a large ball of fire, which exploded with a loud noise, and from which a number of stones were precipitated near Krakhut, a village about fourteen miles from the city of Benares. Mr Davis, the judge and magistrate of the district affirmed that its brilliancy equalled the brightest moonlight. Both he and Mr Erskine, the assistant collector, were induced to send persons in whom they could confide to the spot where this shower of stones was asserted to have taken place, and thus obtained additional evidence of the phenomenon, and several of the stones, which had penetrated about six inches into fields recently watered. Mr Maclane, a gentleman who resided near Krakhut, presented Mr Howard with part of a stone, which had been brought to him the morning after its descent, by the watchman who was on duty at his house, and through the roof of whose hut it had passed, and buried itself several inches in the floor, which was of consolidated earth. Before it was broken, it must have weighed upwards of two pounds.

At the time that this meteor appeared, the sky was perfectly serene; not the smallest vestige of a cloud had been seen since the 11th of the month, nor was any observed for many days after.

" Of these stones (says Mr Howard), I have seen eight nearly perfect, besides parts of several others, which had been broken by the possessors, to distribute among their friends. The form of the more perfect ones appeared to be that of an irregular cube, rounded off at the edges; but the angles were to be observed on most of them. They were of various sizes, from about three to upwards of four inches in their largest diameter; one of them, measuring four inches and a quarter, weighed two pounds twelve ounces. In appearance they were exactly similar; externally they were covered with a hard black coat, or incrustation, which in some parts had the appearance of varnish or bitumen; and on most of them were fractures, which, from their being covered with a matter similar to that of the coat, seemed to have been made in the fall, by the stones striking against each other, and to have passed through some medium, probably an intense heat, previous to their reaching the earth. Internally they consisted of a number of small spherical bodies, of a slate colour, imbedded in a whitish gritty substance, interspersed with bright shining spiculæ, of a metallic or pyritical nature. The spherical bodies were much harder than the rest of the stone: the white gritty part readily crumbled, on being rubbed with a hard body; and on being broken, a quantity attached itself to the magnet, but more particularly the outside coat or crust, which appeared almost wholly attractable by it."

Here we are furnished with another circumstantial and authenticated narrative, by individuals above the rank

Meteorolite.

rank of suspicion, and who were prompted solely by motives of curiosity, to examine with due deliberation the particulars which they have reported.

The history of the extraordinary shower of stones which fell near l'Aigle, in Normandy, on the 26th of April 1803, first appeared in the ensuing artless letter, addressed by M. Marais, an inhabitant of the place, to his friend in Paris.

"*At l'Aigle, the 13th Floréal*, 11.

"An astonishing miracle has just occurred in our district. Here it is, without alteration, addition, or diminution. It is certain, that it is the truth itself.

"On Friday last, 6th Floréal (26th April), between one and two o'clock in the afternoon, we were roused by a murmuring noise like thunder, On going out we were suprised to see the sky pretty clear, with the exception of some small clouds. We took it for the noise of a carriage, or of fire in the neighbourhood. We were then in the meadow, to examine whence the noise proceeded, when we observed all the inhabitants of the Pont de Pierre at their windows, and in gardens, inquiring concerning a cloud, which passed in the direction of from south to north, and from whence the noise issued, although that cloud presented nothing extraordinary in its appearance. But great was our astonishment when we learned, that many and large stones had fallen from it, some of them weighing ten, eleven, and even seventeen pounds, in the space between the house of the Buat family (half a league to the north-north-east of l'Aigle) and Glos, passing by St Nicolas, St Pierre, &c. which struck us at first as a fable, but which was afterwards found to be true.

"The following is the explanation given of this extraordinary event by all who witnessed it.

"They heard a noise like that of a cannon, then a double report still louder than the preceding, followed by a rumbling noise, which lasted about ten minutes, the same which we also heard, accompanied with hissings, caused by these stones, which were counteracted in their fall by the different currents of air, which is very natural in the case of such a sudden expansion. Nothing more was heard; but it is remarkable, that previously to the explosion, the domestic fowls were alarmed, and the cows bellowed in an unusual manner. All the country-folks were much dismayed, especially the women, who believed that the end of the world was at hand. A labourer at la Sapée fell prostrate on the ground, exclaiming, 'Good God! is it possible that thou canst make me perish thus? Pardon, I beseech thee, all the faults I have committed,' &c. The most trifling objects in fact, might create alarm, for it is not improbable, that history offers no example of such a shower of stones as this. The piece which I send was detached from a large one, weighing eleven pounds, which was found between the house of the Buats and le Fertey. It is said, that a collector of curiosities purchased one of seventeen pounds weight, that he might send it to Paris. Every body in this part of the country is desirous of possessing a whole stone, or a fragment of one, as an object of curiosity. The largest were darted with such violence that they entered at least a foot into the earth. They are black on the outside, and grayish, as you see, within, seeming to contain some species of metal and nitre. If you know before us of what ingredients they are composed, you will inform us. One fell near M. Bois de la Ville, who lives near Glos. He was much afraid, and took shelter under a tree. He has found a great number of them of different sizes, in his court-yard, his wheat field, &c. without reckoning all those which the peasants have found elsewhere. Numberless stories, more or less absurd, have been circulated among the people. You know that our country is fertile in such tales. Cousin Moutardier sends one of these stones to Mademoiselle Hébert; and he is not less eager than we are, to know how these substances can be compressed and petrified in the air. Do try to explain the process.

"The person who gave me the largest stone which I send to you, went to take it at the moment that it fell, but it was so hot that it burned him. Several of his neighbours shared the same fate in attempting to lift it.

"The elder Buat has just arrived, and desires us to add, that a fire-ball was observed to hover over the meadow. Perhaps it was wild-fire."

At the sitting of the Institute, on the 9th of May, Fourcroy read a letter, addressed from l'Aigle to Vauquelin, and which sufficiently corroborates the preceding statements. But we pass to the substance of M. Biot's letter, addressed to the minister of the interior, and published in the *Journal des Débats*, (14th Thermidor, year 11.). The writer who is advantageously known for his scientific attainments, was deputed by government to repair to the spot, and collect all the authentic facts. The contents of his letter have been since expanded into the form of a memoir, which manifests the caution and good sense which guided his inquiries, and which we are surprised to learn, has not appeared in an English translation.

M. Biot left Paris on the 25th of June, and in place of proceeding directly to l'Aigle, went first to Alençon, which lies fifteen leagues to the west-south-west of it. He was informed on his way, that a globe of fire had been observed moving towards the north, and that its appearance was followed by a violent explosion. From Alençon he journeyed through various villages to l'Aigle, being directed in his progress by the accounts of the inhabitants, who had all heard the explosion on the day and at the hour specified. Almost all the inhabitants of twenty hamlets, scattered over an extent of upwards of two leagues square affirmed that they were eye-witnesses of a dreadful shower of stones which was darted from the meteor. The following is his summary of the whole evidence.

"On Tuesday, 6th Floréal, year 11, about one o'clock P. M. the weather being serene, there was observed from Caen, Pont d'Audemer, and the environs of Alençon, Falaise, and Verneuil, a fiery globe, of a very brilliant splendour, and which moved in the atmosphere with great rapidity. Some moments after, there was heard at l'Aigle, and in the environs of that town, in the extent of more than thirty leagues in every direction, a violent explosion, which lasted five or six minutes. At first there were three or four reports, like those of cannon, followed by a kind of discharge which resembled the firing of musketry; after which there was heard a dreadful rumbling like the

the beating of a drum. The air was calm, and the sky serene, except a few clouds, such as are frequently observed.

"This noise proceeded from a small cloud which had a rectangular form, the largest side being in a direction from east to west. It appeared motionless all the time that the phenomenon lasted; but the vapours of which it was composed, were projected momentarily from different sides, by the effect of the successive explosions. This cloud was about half a league to the north-north-west of the town of l'Aigle. It was at a great elevation in the atmosphere, for the inhabitants of two hamlets, a league distant from each other, saw it at the same time above their heads. In the whole canton over which this cloud was suspended, there was heard a hissing noise like that of a stone discharged from a sling, and a great many mineral masses exactly similar to those distinguished by the name of *meteor-stones* were seen to fall.

"The district in which these masses were projected, forms an elliptical extent of about two leagues and a half in length, and nearly one in breadth, the greatest dimension being in a direction from south-east to north-west, forming a declination of about 22 degrees. This direction, which the meteor must have followed, is exactly that of the magnetic meridian, which is a remarkable result. The greatest of these stones fell at the south-eastern extremity of the large axis of the ellipse, the middle-sized in the centre, and the smaller at the other extremity. Hence it appears that the largest fell first, as might naturally be supposed. The largest of all those that fell weighs seventeen pounds and a half. The smallest which I have seen weighs about two *gros* (a thousandth part of the last). The number of all those which fell is certainly above two or three thousand."

As we cannot make room for an analysis of M. Biot's more extended communication, we shall be contented to select only two facts.

The *curé* of St Michael declared, that he observed one of the stones fall, with a hissing noise, at the feet of his niece, in the court-yard of his parsonage, and that it rebounded upwards of a foot from the pavement. He instantly requested his niece to fetch it to him; but as she was too much alarmed, a woman who happened also to be on the spot, took it up; and it was found in every respect to resemble the others.

As one *Piche*, a wire-manufacturer belonging to the village of *Armées*, was working with his men in the open air, a stone grazed his arm, and fell at his feet; but it was so hot, that, on attempting to take it up, he instantly let it fall again.

He who compares the various accounts of the l'Aigle meteor, with a critical eye, may detect some apparent contradictions, which, however, on reflection, are found to be strictly conformable to truth. Thus, according to some, the meteor had a rapid motion, others believed it stationary; some saw a very luminous ball of fire, others only an ordinary cloud. Spectators, in fact, viewed it in different positions with respect to its direction. They who happened to be in its line of march, would see it stationary, for the same reason, that we fancy a ship under full sail to be motionless, when we are placed in its wake, or when we view it from the harbour to which it is approaching in a straight line. They, on the other hand, who had a side view of the meteor, would reckon its progress the more rapid, in proportion as their position approached to a right angle with its line of passage. They, again, who saw it from behind, as the inhabitants of l'Aigle, would perceive only the cloud of vapour, which it left in its train, and which, in the dark, would figure like a blazing tail, in the same manner as the smoke of a volcano appears black during the day and red at night. Lastly, they who were placed in front of the meteor, would reckon it stationary, but brilliant and cloudless.

It deserves to be remarked, that the l'Aigle stones were very friable for some days after their descent, that they gradually acquired hardness, and that after they had lost the sulphureous odour on their surface, they still retained it in their substances, as was found by breaking them. Professor Sage submitted them to several comparative trials with those of Ville-franche; and, though the l'Aigle specimens present some globules of the size of a small coriander seed, of a darker gray than the mass, and not attractable by the magnet, yet, in respect of granular texture and general aspect, the coincidence was so striking as to lead one to suppose that they were all parts of the same mass.

The l'Aigle stones, according to Fourcroy, are generally irregular, polygonal, often cuboid, sometimes subcuneiform, and exceedingly various in their diameter and weight. All are covered with a black gravelly crust, consisting of a fused matter, and filled with small agglutinated grains of iron. The greater part of them are broken at the corners, either by their shock against each other, or by falling on hard bodies. The internal parts resemble those of all the stones analyzed by Messrs Howard and Vauquelin, being gray, a little varied in their shades, granulated, and as it were scaly, split in many parts, and filled with brilliant metallic points, exactly of the same aspect as those of other stones of a like description. The proportions of their constituent materials are stated as nearly, 54 silex, 36 oxidated iron, 9 magnesia, 3 nickel, 2 sulphur, and 1 lime, the five per cent. of increase, arising from the oxidation of the metals produced by the analysis.

Of the two specimens which M. Biot presented to the celebrated Patrin, one was less compact, and of a lighter gray than the other, and likewise presented small patches of a rust colour. When immersed in water, it gave a hissing sound, like the humming of a fly, which is held by one wing. As it began to dry, it was observed to be marked by curvilinear and parallel layers. The more compact specimens, when moistened, presented no such appearances, but assumed the aspect of a gray porphyry, with a base of trap, mottled with small white spots, and speckled with metallic points.

Two fine specimens of the l'Aigle stone, one of them nearly entire, may be seen in Mr Ferguson's collection, which we have already repeatedly quoted.

Previously to the explosion of the 26th of April 1803, no meteorolites had been found by the inhabitants of the l'Aigle district, nor in the mineralogical collections of the department; nor the slightest mention of them made in the geological documents of this portion of Normandy: the mines, founderies, and forges, had produced nothing similar, in the form of dross or ore, nor had the country exhibited any trace of volcanoes.

canoes. The meteor at once appears, and a multitude of stones of the peculiar character noted above are seen scattered on a determined space of ground, in a manner, and accompanied with circumstances, which could not formerly have escaped observation. Let us likewise reflect, that the young and the old, simple peasants dwelling at a distance from one another, sagacious and rational workmen, respectable ecclesiastics, young soldiers devoid of timidity, individuals, in short, of various manners, professions, and opinions, united by no common ties, all agree in attesting a fact, which contributed neither directly nor indirectly to promote their own interest, and they all assign the manifestation of this fact to the same day and hour. They, moreover, point to existing vestiges of the descent of solid substances, and they declare, in terms unsusceptible of misconstruction or ambiguity, that they saw the masses in question roll down on roofs, break branches of trees, rebound from the pavement, and produce smoke where they fell. These recitals, and these vestiges, are limited to a tract of territory which has been accurately defined; while beyond the precincts of this tract, not a single particle of a meteorolite has been found, nor a single individual who pretends that he saw a stone fall.

Having now, we presume, advanced ample and satisfactory evidence of the existence of meteorolites, we shall forbear to enlarge this article by dwelling on instances of inferior notoriety to those which we have recounted, and shall merely note the dates of subsequent examples.

On the 4th of July 1803, a fire-ball struck the White Bull Inn at East-Norton, and left behind it several meteoric fragments.—On the 13th of December of the same year, a similar phenomenon occurred at the village of St Nicholas, in Bavaria.—At Possil, near Glasgow in Scotland, a meteor-stone fell, with a loud and hissing noise, on the 5th April 1804.—The next instance which we have to mention occurred near Apt, in the department of Vaucluse, on the 6th of October of the same year: and the last which has come to our knowledge happened at half past five o'clock in the evening of the 15th March 1806, near Alais in Languedoc.

It seems reasonable, however, to suppose, that the fall of meteoric substances takes place more frequently than is commonly supposed, since several foreign collections of fossils contain specimens of reputed celestial origin, and exhibiting the genuine atmospheric physiognomy. It is likewise worthy of remark, that many relations of the phenomenon may have sunk into oblivion, from the contempt with which they were heard by the learned, and that on a fair computation of chances, meteors may have sometimes exploded on desert tracts of land, and still more frequently over the pathless expanse of the water.

That some of the relations to which we have alluded are vague and unsatisfactory, cannot be denied, but the circumstantial testimony conveyed by others is more pointed and positive; and the whole mass of historical proof, especially when combined with the argument deduced from the identity of the physical and chemical constitution of the stones, appears to us to be altogether irresistible.

In the course of our inquiry into this novel and interesting subject, we have ascertained a variety of circumstances which render it highly probable, if not indubitable, that those detached masses of native iron, whose history has so often staggered and perplexed the geologist, are only modifications of meteoric depositions. The Tartars, for example, ascribe the descent of the Siberian mass described by Chladni, Pallas, Patrin, &c. to a period that is lost in the remoteness of antiquity; and while tradition thus favours our hypothesis, the analogy which is obviously observable in point of texture and chemical characters with those of other solid bodies, whose fall is no longer questioned, strengthens tradition. According to the discoveries of Proust and Klaproth, native iron, reputed meteoric, differs from that which occurs in a fossil state by the presence of nickel. The former of these celebrated analysts obtained 50 grains of sulphate of nickel from 100 of the South American mass, and his results are corroborated by Mr Howard and the Count de Bournon.

Of the two pieces of Siberian iron possessed by Mr Greville, one, which was transmitted by Dr Pallas, weighs several pounds; and another presents a cellular and ramified texture, analogous to that of some very light and porous volcanic scoriæ. When attentively examined, there may be perceived in it not only empty cells, but also impressions or cavities of greater or less depth, and in some of which there remains a transparent substance, of a yellowish green colour. The iron itself is very malleable; and may be easily cut with a knife, or flattened under the hammer. The specific gravity is 6487, which is obviously inferior to that of unforged iron that has undergone fusion, and may be partly owing to the oxidizement of the surface of the iron, and partly to the many minute cavities in its substance, which are often rendered visible by fracture, and which have their surface also oxidized. The fracture is shining and silvery, like that of white cast iron; but its grain is much smoother and finer; and it is much more malleable when cold. The heavier specimen is more solid and compact, exhibiting no cavities or pores, though its surface is ramified and cellular. So blended and incorporated is its compact part with the yellowish-green substance mentioned above, that if the whole of the latter could be subtracted, the remainder would consist of iron in the metallic state, and would display the same cellular appearance as the preceding specimen, or as the superficial portion of that now described. This stony part of the composition usually assumes the appearance of small nodules, generally of an irregular shape, but sometimes nearly globular, with a smooth, shining, and glassy surface. This substance, which is always more or less transparent, is hard enough to cut glass, but makes no impression on quartz. It becomes electric by friction, is very refractory, and varies in specific gravity from 3263 to 3300. Of all substances hitherto known, it approaches most to the peridot, or Wernerian chrysolite, which yielded to Klaproth nearly the same results which this substance did to Howard. In the mass of iron, it is liable to decomposition, changing to an opake white, and crumbling into a gritty dry powder, when lightly pressed or squeezed between the fingers.—"I cannot help observing (says the count de Bournon), that there appears to exist a very interesting analogy between these transparent nodules and the globules I described as making part of the stones said to to have fallen on the earth. This analogy, though not a very strong one, may lead us to suppose, that the two substances are similar in their nature, but that the globules are less pure, and contain a greater quantity of iron."

The native iron from Bohemia is compact, like the large specimen from Siberia, in Mr Greville's collection, and like it contains nodules, but not so numerous. They are besides quite opake, and very much resemble the globules in atmospheric stones. This iron contains nearly five per cent. of nickel. Between five and six per cent. of the same metal seems to exist in a piece of native iron brought from Senegal.

Though our limits will not permit us to dwell with minuteness on the physical and chemical characters of meteorolites, we shall shortly state those which the count de Bournon found to appertain to the specimens from Benares, and which may serve as no unfair standard of the aspect and composition of the others.

Like all of the same origin which were subjected to the count's examination, the Benares stones are covered over the whole extent of their surface, with a thin crust, of a deep black colour, sprinkled over with small asperities, which make it feel somewhat like shagreen or fish skin. Their fracture exhibits a grayish colour, and a granulated texture, like that of coarse grit-stone. By help of a lens, they are perceived to be composed of four different substances. One of these occurs in great abundance, in the form of small bodies, some of which are perfectly globular, others rather elongated or elliptical, and all, of various sizes, from that of a small pin's head to that of a pea, or nearly so. These small globules are usually gray, sometimes inclining much to brown, and always opake; they are easily broken in any direction, have a conchoidal fracture, and a fine, smooth, compact grain, with a slight degree of lustre, approaching to enamel; lastly, they can destroy the polish of glass without being able to cut it, and sparkle faintly when struck with steel. Another of these substances is martial pyrites, of an indeterminate form, and reddish yellow colour, slightly verging to the nickel tint, or to that of artificial pyrites; of a somewhat loosely granulated texture, and irregularly distinguished in the mass, being black when reduced to powder, and not attractable by the magnet. The third of these substances consists of small particles of iron, in a perfectly metallic state, so that they may be easily flattened or extended under the hammer. Though in a much smaller proportion than the pyrites just mentioned, they impart the magnetic attraction to the stone. When a piece of the latter was pulverized, and the particles of iron separated from it as accurately as possible, by means of a magnet, they appeared to compose about 200 parts of the weight of the stone. These three substances are united by means of a fourth, which is nearly of an earthy consistency, and of a whitish gray colour.—The black crust, or outward coating, though of very inconsiderable thickness, emits bright sparks when struck with steel, may be broken by the hammer, and seems to possess the same properties with the black oxide of iron, though, like the substance of the stone, it is occasionally intermixed with small particles of iron in the metallic state. These are easily distinguished, by passing a file over the crust, which reveals their lustre. The specific gravity of the Benares stones is 3352.

None of them, when breathed on, emit the argillaceous odour.

In consequence of various experiments, M. Sage, infers that meteorolites are composed of native iron, sulphuret of nickel, quartz or silica, alumina, and magnesia; that the proportions of iron and nickel vary; that the quartz seems to form at least the half of the stone, the alumina and magnesia the sixth, and the sulphur the 30th part. These general results pretty nearly accord with the more special reports of Howard and Vauquelin, except that the latter makes no mention of alumina, the existence of which in atmospheric stones is by no means distinctly ascertained.

We shall only beg leave to add, on this part of our subject, that Laugier, an ingenious chemist, by employing the caustic alkali, has detected a small portion of chrome. The results of his experiments, which are stated in the 58th volume of the *Annales de Chimie*, are 1st, That the five stones from Verona, Barbotan, Ensisheim, l'Aigle, and the neighbourhood of Apt, besides the principles already recognized, contain about one per cent. of chrome. 2dly, That it is very probable that all meteorolites contain this principle, since they all resemble one another in their physical and chemical properties, and have all, apparently, the same origin; and, 3dly, That in many cases, the perfection of chemical analysis requires, that the same substance should be treated both by acids and alkalies, since experience has shown, that a principle which eluded the former method, has been revealed by the latter.

Having now, as we apprehend, sufficiently established the existence and nature of meteorolites, we hope our readers will excuse us from enlarging on the various causes which have been assigned for their origin, as these seem to lie beyond the reach of our present state of knowledge. After a candid and patient review of the principal theories, we conceive that they are at best gratuitous, and that most of them are open to many and formidable objections.

The *terrestrial* hypotheses, we believe, begin already to be generally abandoned, as untenable. Until the phenomenon of exploding meteors had been distinctly observed and recorded, Lemery and others could maintain, with some degree of plausibility, that lightning might tear up the ground, and convert soil into a compact mass. But the appearances of a thunder storm and of a fire-ball are now ascertained to differ in various important respects. Spectators worthy of credit have seen the latter terminate in the fall of solid bodies; and the composition of these solid bodies has been found to differ from that of all the known fossil substances on the surface of the globe. It is in vain, then, to allege, that they are formed on the ground by common lightning, which has often produced very extraordinary effects, but which never generated thousands of stones in fine calm weather. The supposition, that such stones have been projected from some of our volcanoes, is hardly less conceivable. The ashes which accompany a violent eruption of Ætna or Vesuvius have, from their levity, been carried te a very considerable distance; but we are totally unacquainted with any projectile force which could dart solid masses many hundred miles, through such a dense medium as the atmosphere. The compact lavas of burning mountains are never found

found remote from the scene of their formation, and none of them present the characters and aspect of the stones which we have described. M. Bory de St Vincent, indeed, in his *Voyage dans les quatre Principales Isles des Mers d'Afrique*, very pompously expounds a doctrine, which, in our opinion, carries its confutation along with it. According to this writer, meteorolites were projected from immense depths, in an early stage of the earth's existence, when ignivomous mountains were endued with propelling forces sufficient to drive masses of matter into the regions of space, where they were constrained to obey, for ages, the combined laws of impulse and gravitation, until, in the progress of time, their spiral revolutions at length terminated on the surface of their native earth. Before we can adopt such an extravagant hypothesis, we must be convinced, that at one period of the history of our globe, the agency of subterraneous fire was adequate to communicate planetary motion to splinters of rock, without heaving up the rocks themselves, and that the rotatory movement, though once established, must gradually diminish and cease. The demonstration of these positions is surely not less arduous than the explanation of the phenomenon which they are intended to solve.

Of those who contend for the *atmospherical* formation of meteorolites, scarcely any two agree in regard to the manner by which such formation is effected. Patrin, who is solicitous to extend and illustrate his darling theory of volcanoes, labours at great length to maintain the existence of a regular circulation of gaseous fluids between the primitive schistose strata of the globe, and its surrounding atmosphere, and, from this fancied circulation, which he flatters himself he has *demonstrated*, he deduces, quite at his ease, the occasional ignition and concretion of portions of these fluids in the higher regions of the air. This ingenious mineralogist and geologist is so extremely tenacious of these ideas that we shall not attempt to disturb his self-complacency; but he will excuse us if we refuse to assent to results which rest on imaginary foundations. The celebrated Muschenbroeck, in one part of his writings, ascribes the descent of stones from the air to earthquakes and volcanic eruptions, an opinion which later observations have disproved. In other passages, however, he seems to incline to a modification of the atmospherical hypothesis, and endeavours to trace the origin of shooting stars to an accumulation of the volatile matters which are suspended in the air. It is extremely probable, that shooting stars and fiery meteors have an intimate relation to one another, if they are not identical appearances; but it is certain that the former move at a much greater distance from our earth than fire-balls, and only occasion a transient luminous appearance in their passage through the upper regions of the atmosphere. Perhaps they are analogous to those telescopic sparks of light which were observed by M. Schröter. Muschenbroeck, however, adopts the vulgar notion of their falling to the earth, and seems to confound their residue with *tremella nostoc*. M. Salverte has given extension to the theory of formation from vapours, by having recourse to the agency of hydrogen gas. According to him, in consequence of the decomposition of water, which is constantly going on at the surface of the earth, immense quantities of hydrogen gas are continually rising into the atmosphere, and ascending to its higher regions. As this gas is capable of dissolving metals, it carries along with it a portion of iron and nickel. During thunder-storms this gas is kindled by electricity; the metals are deposited, reduced, melted, and vitrified; in other words, meteors are produced and stones formed. This hypothesis is scarcely more satisfactory than the others. It does not account for the presence of magnesia and silica, nor does it explain why the stones are always composed of the same materials. Besides, the existence of hydrogen gas in the atmosphere has not been proved, far less that it forms a separate atmosphere, which is contrary to all experience; and it is well known, that a little hydrogen, mixed with a large portion of atmospheric air, cannot be fired by electricity. In general, we may observe, that if the origin of meteorolites be really atmospherical, the matters of which they are composed must have existed in one of two states, namely, in very attenuated particles or concretions of the matters themselves volatilized and held in solution in the air, or only in the *elements* of these matters. In the first case, when abandoned by their menstruum to their reciprocal tendencies, they would unite by aggregation only; in the second, by chemical combination. Now, we can hardly suppose that disengagement of light and violent detonation should result from the mere affinity of aggregation, whereas they are strictly symptomatic of the affinity of composition. This, and various other considerations which might be stated, if we could make room for them, induce us to regard the doctrine of combination as the most plausible. M. Izarn, who has published a treatise on *Atmospheric Lithology*, has entered into a tedious and somewhat obscure exposition of his own theory, founded on this principle. We shall give the summary, as nearly as we can, in his own words.

"Gaseous substances, arranged in spherical masses in the upper regions of the air, being admitted, the various agitations of the atmosphere should naturally waft some of these masses from their insulating medium into one capable of combining with them. If the combination begins, the disengagement of light is explained. In proportion as the combination advances, the specific gravities are changed; and, consequently, a change of place will commence, and that in the quarter which presents least resistance, or where the medium is most rarefied, in course rather towards the south than the north. Hence, most fire-balls are observed to move from north to south, or from north-east to south-west. Motion being once impressed, the mass traverses other media, capable of supplying new principles, which still increasing the weight, determine the curve; and when at length the principles which are at work, and which issue in all directions, have attained the requisite proportion for extinguishing the elements in the birth of the compound, the grand operation is announced by the explosion, and the product takes its place among the solids."—That the stones in question are produced by chemical combination in the higher regions of the atmosphere, and that they are thus formed from their own elements, are suppositions fully as probable as any that have been advanced on the subject; but whether the union of their parts be effected in the manner detailed by M. Izarn, we are unable to determine, both because we are uncertain if we perfectly comprehend his

Meteorolite.

his meaning, and because our range of data is as yet too circumscribed, to warrant any specific or decisive conclusions.

A much bolder theory has been suggested, and its *possibility* demonstrated by the celebrated French astronomer, La Place, who shews, that meteorolites *may be* the products of lunar volcanoes. As this romantic view of the subject has obtained the suffrages of some men of science, and has excited the ridicule of others, we shall present the reasoning on which it is founded in the popular and perspicuous language of Dr Hutton of Woolwich.

"As the attraction of gravitation extends through the whole planetary system, a body placed at the surface of the moon is affected chiefly by two forces, one drawing it toward the centre of the earth, and another drawing it toward that of the moon. The latter of these forces, however, near the moon's surface is incomparably the greater. But as we recede from the moon, and approach toward the earth, this force decreases while the other augments; till at last a point of station is found between the two planets, where these forces are exactly equal, so that a body placed there must remain at rest; but if it be removed still nearer to the earth, then this planet would have the superior attraction, and the body must fall towards it. If a body then be projected from the moon towards the earth, with a force sufficient to carry it beyond the point of equal attraction, it must necessarily fall on the earth. Such then is the idea of the manner in which the bodies must be made to pass from the moon to the earth, if that can be done, the *possibility* of which is now necessary to be considered

"Now, supposing a mass to be projected from the moon, in a direct line towards the earth, by a volcano, or by the production of steam by subterranean heat; and supposing for the present these two planets to remain at rest; then it has been demonstrated, on the Newtonian estimation of the moon's mass, that a force projecting the body with a velocity of 12,000 feet in a second, would be sufficient to carry it beyond the point of equal attraction. But this estimate of the moon's mass is now allowed to be much above the truth; and on M. la Place's calculation, it appears that a force of little more than half the above power would be sufficient to produce the effect, that is, a force capable of projecting a body with a velocity of less than a mile and a half per second. But we have known cannon balls projected by the force of gunpowder, with a velocity of 2500 feet per second or upwards, that is, about half a mile. It follows, therefore, that a projectile force, communicating a velocity about three times that of a cannon ball, would be sufficient to throw the body from the moon beyond the point of equal attraction, and cause it to reach the earth. Now there can be little doubt that a force equal to that is exerted by volcanoes on the earth, as well as by the production of steam by subterranean heat, when we consider the huge masses of rock, so many times larger than cannon balls, thrown on such occasions to heights also so much greater. We may easily imagine, too, such cause of motion to exist in the moon as well as in the earth, and that in a superior degree, if we may judge from the supposed symptoms of volcanoes recently observed in the moon by the powerful tubes of Dr Herschel; and still more, if we consider that all projections from the earth suffer an enormous resistance and diminution, by the dense atmosphere of this planet; while it has been rendered probable, from optical considerations, that the motion has little or no atmosphere at all, to give any such resistance to projectiles.

"Thus then we are fully authorized in concluding, that the case of *possibility* is completely made out; that a known power exists in nature, capable of producing the foregoing effect, of detaching a mass of matter from the moon, and transferring it to the earth in the form of a flaming meteor, or burning stone: at the same time we are utterly ignorant of any other process in nature by which the same phenomenon can be produced. Having thus discovered a way in which it is possible to produce those appearances, we shall now endeavour to show, from all the concomitant circumstances, that these accord exceedingly well with the natural effects of the supposed cause, and thence give it a very high degree of *probability*.

"This important desideratum will perhaps be best attained, by examining the consequences of a substance supposed to be projected by a volcano from the moon into the sphere of the earth's superior attraction; and then comparing those with the known and visible phenomena of the blazing meteors or burning stones that fall through the air on the earth. And if in this comparison a striking coincidence or resemblance shall always or mostly be found, it will be difficult for the human mind to resist the persuasion that the assumed cause involves a degree of probability but little short of certainty itself. Now the chief phenomena attending these blazing meteors or burning stones, are these: 1. That they appear or blaze out suddenly. 2. That they move with a surprising rapid motion, nearly horizontal, but a little inclined downwards. 3. That they move in several different directions with respect to the points of the compass. 4. That in their flight they yield a loud whizzing sound. 5. That they commonly burst with a violent explosion and report. 6. That they fall on the earth with great force in a sloping direction. 7. That they are very hot at first, remain hot a considerable time, and exhibit visible tokens of fusion on their surface. 8. That the fallen stony masses have all the same external appearance and contexture, as well as internally the same nature and composition. 9. That they are totally different from all our terrestrial bodies, both natural and artificial.

"Now these phenomena will naturally compare with the circumstances of a substance projected by a lunar volcano, and in the order in which they are here enumerated. And first, with respect to the leading circumstance, that of a sudden blazing meteoric appearance, which is not that of a small bright spark, first seen at at immense distance, and then gradually increasing with the diminution of its distance. And this circumstance appears very naturally to result from the assumed cause. For, the body being projected from a lunar volcano, may well be supposed in an ignited state, like inflamed matter thrown upon by our terrestrial volcanoes, which passing through the comparatively vacuum, in the space between the moon and the earth's sensible atmosphere, it will probably enter the superior parts of this atmosphere with but little diminution of its original

nal heat; from which circumstance, united with that of its violent motion, this being 10 or 12 times that of a cannon ball, and through a part of the atmosphere probably consisting chiefly of the inflammable gas rising from the earth to the top of the atmosphere, the body may well be supposed to be suddenly inflamed, as the natural effect of these circumstances; indeed it would be surprising if it did not. From whence it appears, that the sudden inflammation of the body, on entering the earth's atmosphere, is exactly what might be expected to happen.

"2. To trace the body through the earth's atmosphere; we are to observe that it enters the top of it with the great velocity acquired by descending from the point of equal attraction, which is such as would carry the body to the earth's surface in a very few additional seconds of time if it met with no obstruction. But as it enters deeper in the atmosphere, it meets with still more and more resistance from the increasing density of the air, by which the great velocity of six miles per second must soon be greatly reduced to one that will be uniform, and only a small part of its former great velocity. This remaining part of its motion will be various in different bodies, being more or less as the body is larger or smaller; and as it is more or less specifically heavy; but, for a particular instance, if the body were a globe of 12 inches diameter, and of the same gravity as the atmospheric stones, the motion would decrease so as to be little more than a quarter of a mile per second of perpendicular descent. Now while the body is thus descending, the earth itself is affected by a twofold motion, both the diurnal and the annual one, with both of which the descent of the body is to be compounded. The earth's motion of rotation at the equator is about 17 miles in a minute, or two-sevenths of a mile in a second; but in the middle latitudes of Europe little more than the half of that, or little above half a quarter of a mile in a second; and if we compound this motion with that of the descending body, as in mechanics, this may cause the body to appear to descend obliquely, though but a little, the motion being nearer the perpendicular than the horizontal direction. But the other motion of the earth, or that in its annual course, is about 20 miles in a second, which is 80 times greater than the perpendicular descent in the instance above mentioned; so that, if this motion be compounded with the descending one of the body, it must necessarily give it the appearance of a very rapid motion, in a direction nearly parallel to the horizon, but a little declining downwards. A circumstance which exactly agrees with the appearances of these meteoric bodies, as stated in the second article of the enumerated phenomena.

"3. Again, with regard to the apparent direction of the body; this will evidently be various, being that compounded of the body's descent and the direction of the earth's annual motion at the time of the fall, which is itself various in the different seasons of the year, according to the direction of the several points of the ecliptic to the earth's meridian or axis. Usually, however, from the great excess of the earth's motion above that of the falling body, the direction of this must appear to be nearly opposite to that of the former. And in fact this exactly agrees with a remark made by Dr Halley, in his account of the meteors in his paper above given, where he says that the direction of the meteor's motion was exactly opposite to that of the earth in her orbit. And if this shall generally be found to be the case, it will prove a powerful confirmation of this theory of the lunar substances. Unfortunately, however, the observations on this point are very few, and mostly inaccurate; the angle or direction of the fallen stones has not been recorded; and that of the flying meteor commonly mistaken, all the various observers giving it a different course, some even directly the reverse of others. In future, it will be very advisable that the observers of fallen stones, observe and record the direction or bearing of the perforation made by the body in the earth, which will give us perhaps the course of the path nearer than any other observation.

"4. In the flight of these meteoric stones, it is commonly observed, that they yield a loud whizzing sound. Indeed it would be surprising if they did not. For if the like sound be given by the smooth and regularly formed cannon ball, and heard at a considerable distance, how exceedingly great must be that of a body so much larger, which is of an irregular form and surface too, and striking the air with 50 or 100 times the velocity.

"5. That they commonly burst and fly in pieces in their rapid flight, is a circumstance exceedingly likely to happen, both from the violent state of fusion on their surface, and from the extreme rapidity of their motion through the air. If a grinding stone, from its quick rotation, be sometimes burst and fly in pieces, and if the same thing happen to cannon balls when made of stone and discharged with considerable velocity, merely by the friction and resistance of the air; how much more is the same to be expected to happen to the atmospheric stones, moving with more than 50 times the velocity, and when their surface may well be supposed to be partly loosened or dissolved by the extremity of the heat there.

"6. That the stones strike the ground with a great force, and penetrate to a considerable depth, as is usually observed, is a circumstance only to be expected from the extreme rapidity of their motion, and their great weight, when we consider that a cannon ball, or a mortar shell, will often bury itself many inches, or even some feet in the earth.

"7. That these stones, when soon sought after and found, are hot, and exhibit the marks of recent fusion, are also the natural consequences of the extreme degree of inflammation in which their surface had been put during their flight through the air.

"8. That these stony masses have all the same external appearance and contexture, as well as internally the same nature and composition, are circumstances that strongly point out an identity of origin, whatever may be the cause to which they owe so generally uniform a conformation. And when it is considered,

"9. That in those respects they differ totally from all terrestrial compositions hitherto known or discovered, they lead the mind strongly to ascribe them to some other origin than the earth we inhabit; and none so likely as coming from our neighbouring planet.

"Upon the whole then (continues Dr Hutton), it appears

appears highly probable, that the flaming meteors, and the burning stones, that fall on the earth, are one and the same thing. It also appears impossible, or in the extremest degree improbable, to ascribe these either to a formation in the superior parts of the atmosphere, or to the eruptions of terrestrial volcanoes, or to the generation by lightning striking the earth. But, on the other hand, that it is possible for such masses to be projected from the moon so as to reach the earth; and that all the phenomena of these meteors or falling stones, having a surprising conformity with the circumstances of masses that may be expelled from the moon by natural causes, unite in forming a body of strong evidence, that this is in all probability and actually the case.

M. Poisson, an ingenious French mathematician, has shown by an algebraical calculation, the possibility of a projectile reaching our planet from the moon. His calculation, however, which may be found in the work of Izarn, quoted above, (p. 238. et seq.) proceeds on the supposition that our satellite has no atmosphere, or next to none. There are, no doubt, appearances which seem to favour this supposition, but they do not amount to positive proof of the fact. Even could the latter be established, the combustion of a volcano, without the presence of atmospheric air, would remain to be explained. But, granting this difficulty too to be surmounted, there are other circumstances which we cannot easily reconcile to the lunar hypothesis. The occasional arrival of fragments of lava on the earth's surface, would argue, on a fair computation of chances, such a copious discharge of volcanic matters, that the moon, by this time, would consist of hardly any thing else. Again, if we may be allowed to reason from analogy, the volcanic productions of the moon should exhibit varieties of aspect and composition like those with which we are acquainted, and not a definite and precise number of the same ingredients. We may also remark, that the soft and incoherent state of several of the recent specimens of meteorolites can ill accord with their supposed passage through any considerable portion of space; and that the l'Aigle phenomenon, which is so distinctly recorded, evidently suggests the notion of instantaneous formation in the atmosphere. And, though this view of the subject may be regarded by some as inexplicable, we cannot conceive that it is more so than the doctrine of crystallization, or than many of the results of chemical combination, whose existence it is impossible to deny. These and other arguments may, we apprehend, be fairly urged against any theory which attempts to explain the history of meteors by the agency of lunar volcanoes.

The hypothesis of Dr Chladni, which likewise boasts of its advocates, though still more extravagant than the preceding, deserves to be stated. As earthy, metallic, and other particles form the principal component parts of our planet, among which iron is the prevailing part, other planetary bodies, he affirms, may consist of similar, or, perhaps, the same component parts, though combined and modified in a very different manner. There may also be dense matters accumulated in smaller masses, without being in immediate connexion with the larger planetary bodies, dispersed throughout infinite space, and which, being impelled either by some projecting power or attraction, continue to move until they approach the earth, or some other body; when, being overcome by attractive force, they immediately fall down. By their exceeding great velocity, still increased by the attraction of the earth and the violent friction in the atmosphere, a strong electricity and heat must necessarily be excited, by which means they are reduced to a flaming and melted condition, and great quantities of vapour and different kinds of gases are thus disengaged, which distend the liquid mass to a monstrous size, till, by a still farther expansion of these elastic fluids, they must at length displode. That portions of cosmical matter are allowed to revolve in space, and to terminate their career on the surface of a planet, is a position too gratuitous and vague, to be readily admitted, but the belief of which involves no principle of atheism or impiety, as some of Dr Chladni's antagonists have very unhandsomely insinuated. If worlds disappear and others spring into existence, a sportive imagination may be permitted to indulge in the innocent supposition, that fragments of their materials are detached from their fractured masses, and obey those laws of attraction which seem to extend their influence to the remotest corners of the universe.

Such of our readers as are solicitous of obtaining more ample information on the subject of this article, may consult *Izarn's Lithologie Atmospherique; Biot's Relation d'un Voyage fait dans le departement de l'Orne, pour constater la réalité d'un Météore observè à l'Aigle; Böttiger's Observations on the Accounts given by ancient authors of Stones said to have fallen from the Clouds; Fulda's Memoir on Fire-balls; Cavallo's Elements of Natural Philosophy; Klaproth on Meteoric Stones; Soldani's Account of the Tuscan Meteor; Chladni's Treatise on the Siberian Mass of Iron; Mr Edward King's Remarks concerning Stones said to have fallen from the Clouds;* and several of the more recent transactions of learned societies and periodical scientific communications, as those of the Royal Society of London, of the Institute at Paris, the Journal de Physique, Annales de Chimie, Bibliotheque Britannique, Decade Philosophique, Journal des Mines, Philosophical Magazine, Nicholson's Journal, &c. &c.

METEOROLOGICAL, something belonging to meteors.

METEOROLOGICAL Journal, is a table recording the daily state of the air, exhibited by the barometer, thermometer, hygrometer, anemometer, and other meteorological instruments. We have many journals of this kind, kept at the house of the Royal Society, and by different observers in other places, in the Philosophical Transactions, the Memoirs of the Academy of Sciences, and similar publications.

METEOROLOGY.

INTRODUCTION.

1 bject of eteoro- gy.

METEOROLOGY is that part of natural science which treats of the changes that take place in our atmosphere, as they are perceptible to our senses, or as they are indicated by certain instruments which the ingenuity of man or accident has discovered to answer that purpose. In as far as it describes the phenomena produced by such changes, meteorology is a department of natural history; but in its attempts to account for the appearances, it is almost entirely dependent on NATURAL PHILOSOPHY and CHEMISTRY.

2 s connec- on with emistry.

The connection of METEOROLOGY with CHEMISTRY is sufficiently evident to those who take only a superficial view of the subject, though it has only of late attracted the notice of philosophers. That the air is sometimes hotter and sometimes colder than usual; that it is at one time much rarefied, and at another greatly condensed; now uncommonly dry, and now surcharged with moisture—are circumstances that daily meet the senses of the most casual observer, as they are circumstances that powerfully, and often unpleasantly, arrest his attention. That these changes are the result of decompositions and combinations that are continually going on in the atmosphere, and of new modifications of its component principles, is manifest to him who is acquainted merely with the first elements of modern chemistry.

3

Indeed to modern chemistry this science is indebted for the progress it has made within the last 50 years; a period which may be considered as the second epoch of meteorology. In fact, this science is still in its infancy; but from the ardour with which it is now cultivated, from the abilities of the philosophers who are engaged in the study, and from the progress that is daily making in the kindred sciences, we may reasonably look forward to a period, at no great distance, when it shall please the great Author of nature to unveil many of those wonders which are now involved in darkness and obscurity, and permit us to controul the jarring elements, as he has allowed us to exercise dominion over the beasts of the earth, the fowls of the air, and the fishes of the sea.

4 Ieans of nproving ieteoro- gy.

A late ingenious writer on the climate of Britain has suggested some useful hints for the improvement of meteorology, which we shall here extract. "With this view, our first step must be *that* recommended by Mr Kirwan and others, to establish corresponding societies in different parts of the world; these societies must be furnished with similar apparatus, equally adjusted, and graduated in their construction, for making observations on the weather. In our own island it will be necessary to procure registers, carefully kept, from the different parts of the sea coast, and from those parts of the country situated in the interior. The various states of the barometer, thermometer, hygrometer, and electroscope, should be carefully noted; with the variations and the degrees of wind, as well as the diurnal and nocturnal aspect of the heavens discriminately marked; the appearance of the sky; and in familiar language, such as might be understood by the respective and distant observers; for instance, whether the sun is totally or partially obcured by vapour;—whether the clouds are mottled, or fleaky;—whether they assume the appearance of horizontal streaks, or appear in radii apparently from a centre—or in masses of dense vapour—or loose and fleecy—or those familiarly known by the name of *mare-tail* clouds—with any other new or accustomed phenomena. The common terms *fair*, *cloudy*, or *wet*, are insufficient for forming a judgment of the weather; as the term fair is generally at present expressed only in opposition to *rain*, without distinguishing whether the atmosphere is obscure, dull, or bright. The appearance of the stratum of air on the earth's surface, *that is, the space between the clouds and the earth*, should be always accurately described. Is there a blue haze, white mist, and dense fog? or is the air transparent? which is the case when distant objects appear more than commonly distinct and near to the eye of the observer: the temperature of the ocean at *full tide* should be frequently ascertained, as it will be found to have considerable influence in these respects on an insular country. By the remarks of observers, stationed in various parts of our coasts, we should soon be enabled to discover when vapour is wafted in from the sea, or generated by the aqueous and vegetable surface of our island. During a north-west wind, which is frequently attended with storms of hail and rain, and usually experienced in the spring, an observer stationed on the coast of Sligo in Ireland, or Denbighshire in Wales, might ascertain whether the disposition of the atmosphere to storm and cloud came in with the air from the Atlantic ocean, or was generated by the vapours of our own island. It would be desirable also again, that the temperature and blue hazy appearance of the atmosphere during the north-east winds, so common in May and June, should be noticed by observers on the north-east coast, in the counties of York, Lincoln, Essex, and Kent; and by others, on the opposite western coasts of Pembroke, Devon, and Cornwall, so as to determine what changes in temperature this wind undergoes in its passage over the island; and whether or not the degree of haze increases or diminishes by its progress from either quarter; and whether the vapour is more or less disposed to produce storms?

By such comparative observations on the coast, conjoined with those made by others in the central parts of the kingdom, we might rapidly proceed in meteorological science, or, as it is commonly called, a knowledge of the weather. The observations made in the interior of the country would enable us at all times to trace the origin and progress of storms: in situations where tillage or pasturage is most attended to, the effects of spring frosts and blights should be particularly noticed, as well as the first appearance of the aphis and coccus, the caterpillar and larvæ of other insects, on fruit trees, and particularly those peculiar to the *hop plantations*. The first opening of the vernal foliage on trees and hedges in the spring, should likewise be remarked, and compared with the starting up grass on the highly

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highly manured pastures in the neighbourhood of towns, and on those also assisted with manure, as well as the natural herbage on the commons and wastes. Some attention should be paid to the effects of thunder storms, in destroying the aphis and other destructive insects, the pest of fruit and hop plantations; and the first appearance of the mildew or rust on wheat should be particularly observed, and remarks made to ascertain, whether or not the moisture, which occasions the disease in its commencement was attended with wind and rain, or a close damp state of the air. The different kinds of soil, where the crops, from the disease, suffered most, should be noticed, and the situation of the land for ventilation, with the height of the fences, size of inclosures, and vicinity to coppices, trees, or hedge-rows*."

* *Williams on the Climate of Britain.*

Importance of the science.

The importance of the study of meteorology requires little elucidation. In climates where the succession of seasons is nearly stated and regular, where the periods of parching drought or deluging torrents, of the tempestuous hurricane or the refreshing breeze, are fixed and ascertained, mankind has little to do, but expect the dreaded changes, and provide against their devastations; but in countries like our own, where all the vicissitudes of seasons may take place in the course of a few hours, it is of the highest consequence to investigate the nature of the change, and the circumstances that precede or accompany it. To the farmer, the mariner, the traveller, the physician, meteorology is in some measure a study of necessity; to the philosopher it is a study of interest and delight; and to the observer of nature it affords objects of grandeur and sublimity not to be found in any other department of his favourite science. Surely nothing can contribute more to elevate the mind of man, to raise it "from nature up to nature's God," than the contemplation of the sweeping whirlwind, the dazzling lightning, or the awful thunder.

Our limits will not admit of our entering into a historical detail of the progress of meteorology; but it may be proper in this place to enumerate the principal writers on this science both in our own country and on the continent.

6 Writers on meteorology.

In this country, we may reckon Dr Kirwan, (in his "Estimate of the Temperature of different Climates"), his "Essay on the Variations of the Atmosphere," and in the Irish Transactions," Mr John Dalton (chiefly in the "Manchester Memoirs"), Col. Capper (in his "Observations on the Winds and Monsoons"), Mr Williams (in his "Climate of Great Britain"), and Mr Luke Howard (in the Philosophical Magazine), as the principal cultivators of meteorological knowledge; and on the continent, the names of Cotte ("*Traite de Metcorologie*," and *Journal de Physique*), Saussure ("*Essai sur l'Hygrometrie*," and *Voyage aux Alpes*"), De Luc (A) ("*Recherches sur les Modifications de l'Atmosphere*," "*Idees sur la Meteorologie*," and other works), and Lamarck (see *Journ. de Phys.* passim) stand most conspicuous in this branch of natural science. The names of some of the more recent writers are mentioned in the article METEOROLOGY, SUPPLEMENT, which see.

7 In considering the subject of meteorology, we may properly divide it into seven general heads: 1. Of the changes which take place in the gravity of the air; 2. Of the changes of the temperature of the air; 3. Of the changes produced by evaporation and rain; 4. Of the changes produced by winds; 5. Of atmospherical electricity; 6. Of meteors, or those visible phenomena accompanied with light, which take place in the atmosphere or near the surface of the earth; and, 7. The application of the principles of meteorology to the useful purposes of life. Of these heads, the fifth has been already fully considered under ELECTRICITY, and much of the sixth has been exhausted under METEOROLITE. The remaining circumstances will form the subjects of the following chapters.

CHAP. I. *Of the Changes which take place in the Gravity of the Air.*

MANY of the facts relating to this part of our subject have been already anticipated under the article BAROMETER, and several circumstances fall to be considered more properly under PNEUMATICS than in this place. We shall here confine ourselves to a general view of the changes in the gravity of the atmosphere, as indicated by the barometer, in various situations on or near the surface of the earth, and briefly examine the conclusions that may be drawn from them.

8 Mercury stands highest at the level of the sea.

The most general fact indicated by the barometer is, that this instrument shews us the weight of a column of air

(A) In again mentioning the name of a philosopher so respectable as M. de Luc, we embrace the first opportunity of doing him justice, and of vindicating his character against an unfortunate misconception of the late Professor Robison, a mistake which we have inadvertently contributed to disseminate, by quoting Dr Robison's statement in our account of Dr Black, where M. de Luc is accused of having arrogated to himself Dr Black's discovery of *latent heat*.

M. de Luc's vindication of himself (as printed in the 12th number of the Edinburgh Review) is before the public. We owe it to candour and justice to acknowledge our conviction that Dr Robison was too hasty in his assertion, and that M. de Luc, so far from arrogating to himself the doctrine of *latent heat*, has, in various parts of his numerous writings, expressly mentioned Dr Black as the author of that doctrine. This will appear from the following citations. In his "Introduction à la Physique terrestre," p. 102, M. de Luc thus expresses himself. "Ne connoissant point le *feu latent*, dans la vapeur à toute temperature, *dont la premiere decouverte est due au* Dr Black, &c. Again, p. 232. of the same work. "Ce qui developpoit l'idée de *chaleur latente par laquelle le Dr Black avoit designé ce phénomêne*,"—and at p. 385, "Le Dr Black ayant découvert qu'une certaine quantité de chaleur disparoit quand la vapeur de l'eau bouillante se forme, *nomma ce phénoméne chaleur latente* dans la vapeur."

We trust that these quotations, with M. de Luc's own justification of himself above referred to, will be sufficient to exculpate him from the charge of *literary felony* so warmly brought against him by Professor Robison; and we have no doubt the Professor himself, were he still alive, would under such evidence retract his accusation.

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air whose base is equal to the diameter of the mercury in the tube, and whose height is equal to the extent of the atmosphere above the place of observation. As the height of this column must vary in different situations, and must, *cæteris paribus*, be greatest at the level of the sea, the mercury in the tube will, under the same circumstances, stand highest in such a situation.

9 Medium height 30 inches.

The medium height of the barometer at the level of the sea is 30 inches, as has been found by observations in the British channel, and in the Mediterranean sea, at the temperatures of 55° and 60°; on the coast of Peru at the temperature of 84°, and in latitude 80°. As we ascend above the surface of the earth, the medium height of the mercury diminishes; and some late observations made in balloons at a considerable distance above the tops of the highest mountains, have shewn that in the higher regions of the air, the column of mercury is very considerably shortened. This fact, as we have seen (see BAROMETER), has been usefully applied to the measuring of heights and depths that cannot be ascertained by the usual geometrical methods. As the absolute gravity of the atmosphere is constantly varying even in the same place, the column of air pressing on the surface of the mercury without the tube, must press with more or less force, in proportion as these changes are greater; and hence the barometer points out these variations, falling when the atmosphere is lighter, and rising when it is heavier than usual. For an account of the observations that were made on the rise and fall of the barometer by the earlier philosophers, and the attempts which were made by them to explain these phenomena, see BAROMETER.

It will be of advantage here to consider the variations of the barometer, as they take place in different situations, in order, if possible, to point out the cause by which these variations are produced, as this cause must have considerable influence on the changes of the weather.

10 [V]ariation [in] the baro[m]eter be[tw]een the [tr]opics very [sm]all.

It is found, that between the tropics the variations of the barometer are exceedingly small, and it is remarkable, that in that part of the world it does not descend above half as much for every 200 feet of elevation as it does beyond the tropics *. In the torrid zone, too, the barometer is elevated about $\frac{2}{3}$ of a line twice every day; and this elevation happens at the same time with the tides of the sea †.

As the latitude advances towards the poles, the range of the barometer gradually increases, till at last it amounts to two or three inches. This gradual increase will appear from the following table.

Table of the Range of the Barometer.

Latitude.	Places.	Range of the Barometer.	
		Greatest	Annual.
0°	Peru	0.20 *	
22 23′	Calcutta	0.77 †	
40 55	Naples	1.00 ‡	
51 8	Dover	2.47 §	1.80
53 13	Middlewick	3.00 §	1.94
53 23	Liverpool	2.89 ‖	1.96
59 56	Petersburgh	3.45 **	2.77

* [J]our. de [P]hys. 1790. [p.] 268.
† Ibid.

* Kirw. [Ir]ish Trans. [vo]l. iii. 47.
† Asiatic [R]esearches, [vo]l. ii. Ap[pe]ndix.
‡ Manchest. [M]em. vol.
§ Edin. [Tr]ans. vol.
‖ Trans. [Ph]iladelph. [vo]l. ii.
** Edin. [Tr]ans. vol. p. 229.

There is, however, some exception to this general rule, as in North America the range of the barometer is much less than in the corresponding European latitudes.

The range of the barometer is greater at the level of the sea than on mountains, and in the same degree of latitude the extent of the range is in the inverse ratio of the height of the place above the level of the sea.

It appears probable that the barometer has a tendency to rise during the day from morning to evening, and that this tendency is greatest between 2 and 9 P. M. the greatest elevation being at this last period. The elevation at 2 differs from that at 9 by $\frac{4}{12}$, while that at 2 differs from the morning elevation only by $\frac{1}{12}$; and that in certain climates the greatest elevation takes place at 2 o'clock *.

The range of the barometer is greater in winter than in summer, as appears from some observations made at Kendal during five years; the mean range from October to March being 7.982, and that from April to September being only 5.447 †.

* Jour. de Phys. 1790. p. 11.

† Manchest. Mem. vol. iv. p. 547.

When the atmosphere is serene and settled the mercury is generally high; and in calm weather, when it is inclined to rain, the mercury is low. On the approach of high winds it sinks, as it does with a southerly wind, but rises very high on the approach of easterly and northerly winds. It is found, however, that at Calcutta the mercury is highest with north-westerly and northerly, and lowest with south-easterly winds.

The mercury suddenly falls on the approach of tempests, and during their continuance undergoes great oscillations.

To these general facts that have been observed on the rise and fall of the barometer, we shall annex the following axioms by M. Cotte. 12

Cotte's axioms on the barometer.

1. The greatest changes of the barometer commonly take place during clear weather, with a north wind; and the small risings during cloudy, rainy, or windy weather, with a south, or nearly south wind.

2. The state of the mercury changes more in the winter than in the summer months; so that its greatest rising and falling takes place in winter; but its mean elevation is greater in summer than in winter.

3. The changes of the state of the barometer are nearly null at the equator, and become greater the more one removes from it towards the poles.

4. They are more considerable in valleys than on mountains.

5. The more variable the wind, the more changeable the state of the barometer.

6. It is lower at midnight and noon than at other periods of the day; its greatest daily height is towards evening.

7. Between 10 at night and 2 in the morning, and also in the day, the rising and falling of the mercury are less; the contrary is the case between 6 and 10 in the morning and evening.

8. Between 2 and 6 in the morning and evening it rises as often as it falls; but in such a manner that it oftener rises about that time in the winter months, and falls oftener in the summer months.

9. The oscillations are less in summer, greater in winter, and very great at the equinoxes.

10. They

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10. They are greater also in the daytime than during the night.

11. The higher the sun rises above the horizon, the less are the oscillations; they increase as he approaches the western side of the horizon, and are exceedingly great when he comes opposite to the eastern part of the horizon.

12. They are, to a certain degree, independent of the changes of temperature.

13. The mercury generally rises between the new and the full moon, and falls between the latter and the new moon.

14. It rises more in the apogee than the perigee; it usually rises between the northern lunistice and the southern, and falls between the southern lunistice and the northern.

15. In general, a comparison of the variations of the mercury with the positions of the moon gives nothing certain; the results of N° 13. and 14. are the most constant.

16. In the neighbourhood of Paris the barometer never continues 24 hours without changing.

17. The barometers in the western districts rise and fall sooner than those in the more eastern.

18. When the sun passes the meridian, the mercury, if falling, continues to fall, and its fall is often hastened.

19. When the mercury at the same period is rising, it falls, remains stationary, or rises more slowly.

20. When the mercury, under the same circumstances, is stationary, it falls, unless, before or after it becomes stationary, it has been in the act of rising.

21. The above changes commonly take place between 11 in the morning and 1 in the afternoon, but oftener before than after noon.

22. Before high tides there is almost always a great fall of the mercury; this takes place oftener at the full than the new moon.

Such is a general view of the variations in the gravity of the air, as far as they have been observed by the barometer; and we shall now endeavour to give some plausible theory of them.

13 Atmosphere forms two inclined planes meeting at the equator.

It is evident that the density of the atmosphere is least at the equator, and greatest at the poles; for at the equator the centrifugal force, the distance from the centre of the earth, and the heat (all of which tend to diminish the density of the air), are at their maximum, while at the poles they are at their minimum. The mean height of the barometer at the level of the sea, all over the globe, is 30 inches; the weight of the atmosphere, therefore, is the same all over the globe. This weight depends on the density and height of the air; where the density is greatest, its height must be least; and on the contrary, where its density is least, its height must be greatest. The height of the atmosphere, therefore, must be greatest at the equator, and least at the poles; and it must decrease gradually between the equator and the poles, so that its upper surface will resemble two inclined planes, meeting above the equator their highest parts *.

During summer, when the sun is in our hemisphere, the mean heat between the equator and the pole does not differ so much as in winter. Hence the rarity of the atmosphere at the pole, and consequently its height, will be increased. The upper surface of the atmosphere, therefore, in the northern hemisphere, will be less inclined; while that of the southern hemisphere, from contrary causes, will be much more inclined. The reverse will take place during our winter.

The density of the atmosphere depends in a great measure on the pressure of the superincumbent column, and therefore decreases according to the height, as the pressure of the superincumbent column constantly decreases. But the density of the atmosphere in the torrid zone will not decrease so fast as in the temperate and frigid zones, because its column is larger, and because there is a greater proportion of air in the higher part of this column. This accounts for the observation of Mr Casson, that the barometer sinks only half as much for every 200 feet of elevation in the torrid as in the temperate zones. The density of the atmosphere at the equator, therefore, though at the surface of the earth it is less, must at a certain height equal, and at a still greater must exceed, the density of the atmosphere in the temperate zones and at the poles.

14 Why the mercury is highest in winter in northern latitudes.

We shall presently endeavour to prove, that a quantity of air is constantly ascending at the equator, and that part of it at least reaches and continues in the higher parts of the atmosphere. From the fluidity of air it is evident that it cannot accumulate above the equator, but must roll down the inclined plane which the upper surface of the atmosphere assumes towards the poles. As the surface of the atmosphere of the northern hemisphere is more inclined during our winter than that of the southern hemisphere, a greater quantity of the equatorial current of air must flow over upon the northern than upon the southern hemisphere; so that the quantity of our atmosphere will be greater during winter than that of the southern hemisphere; but during summer the reverse will take place. Hence the greatest mercurial heights take place during winter, and the range of the barometer is less in summer than in winter.

The density of the atmosphere is in a great measure regulated by the heat of the place; wherever the cold is greatest, there the density of the atmosphere will be greatest, and its column shortest. High countries, and ranges of lofty mountains, the tops of which are covered with snow the greatest part of the year, must be much colder than other places situated in the same degree of latitude, and consequently the column of air over them much shorter. The current of superior air will linger and accumulate over these places in its passage towards the poles, and thus occasion an irregularity in its motion, which will produce a similar irregularity in the barometer. Such accumulations will be formed over the north-western parts of Asia, and over North America; hence the barometer usually stands higher, and varies less there, than in Europe. Accumulations also are formed upon the Pyrenees, the Alps, the mountains of Africa, Turkey in Europe, Tartary, and Tibet. When these accumulations have gone on for some time, the density of the air becomes too great to be balanced by the surrounding atmosphere; it rushes down on the neighbouring countries, and produces cold winds which raise the barometer. Hence the rise of the barometer which generally attends north-east winds in Europe, as they proceed from accumulations in the north-west of Asia, or about the pole; hence, too, the north-west wind from the mountains of Tibet raises the barometer at Calcutta.

* *Irish Trans* vol. ii. p. 43, &c.

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ravity of he Air. We shall presently endeavour to shew, that considerable quantities of air are occasionally destroyed in the north polar regions. When this happens, the atmosphere to the south rushes in to supply the deficiency. Hence south-west winds take place, and the barometer falls.

As the mean heat of our hemisphere differs in different years, the density of the atmosphere, and consequently the quantity of equatorial air which flows towards the poles, must also be variable. Does this range correspond to the mean annual heat; that is to say, Is the range greatest when the heat is least, and least when the heat is greatest? In some years greater accumulations than usual take place in the mountainous parts of the south of Europe and Asia, owing, perhaps, to earlier falls of snow or to the rays of the sun having been excluded by long-continued fogs. When this takes place, the atmosphere in the polar regions will be proportionably lighter. Hence the prevalence of southerly winds during some winters more than others.

As the heat in the torrid zone never differs much, the density, and consequently the height, of the atmosphere, will not vary much. Hence the range of the barometer within the tropics is comparatively small; and it increases gradually as we approach the poles, because the difference of the temperature, and consequently of the density, of the atmosphere, increases with the latitude.

The diurnal elevation of the barometer in the torrid zone corresponding to the tides, observed by Mr Casson and others, must be owing to the influence of the moon on the atmosphere. This influence, notwithstanding the ingenious attempts of D'Alembert and several other philosophers, seem altogether inadequate to account for the various phenomena of the winds. It is not so easy to account for the tendency which the barometer has to rise as the day advances. Perhaps it may be accounted for by the additional quantity of vapour added to the atmosphere, which by increasing the quantity of the atmosphere, may possibly be adequate to produce the effect.

The falls of the barometer which precede, and the oscillations which accompany, violent storms and hurricanes, shew us that these phenomena are produced by very great rarefactions, or perhaps destructions of air, in particular parts of the atmosphere. The falls of the barometer, too, that accompany winds, proceed from the same cause. The observation made by Mr Copland, that a high barometer is accompanied by a temperature above the mean, will be easily accounted for by every one acquainted with Dr Black's theory of latent heat. The higher the mercury stands, the denser the atmosphere must be; and the denser it becomes, the more latent heat it must give out. It is well known that air evolves heat when condensed artificially. The falling of the barometer, which generally precedes rain, remains still to be accounted for; but we know too little about the causes by which rain is produced, to be able to account for it in a satisfactory manner.

It has been for some time suspected that the variation of the barometer is affected by the changes of the moon. The theory of lunar influence has been discussed on the continent chiefly by Lamarck and Cotte, (see Journal de Physique, *passim*); and in this country by Mr Luke Howard. Mr Howard's suspicions of this influence on the barometer were first conceived, in consequence of the printed charts, of which he made use in keeping a register of the barometer, having the phases of the moon marked on them, and of his observing a remarkable coincidence between these and certain states of the mercury. This coincidence consists in the depression of the barometrical line on the approach of the new and full moon, and its elevation on that of the quarters. In above 30 out of the 50 lunar weeks in the year 1798, the barometer was found to have changed its general direction once in each week, in such a manner as to be either rising or at its *maximum*, for the week preceding and following, about the time of each quarter; and to be either falling or at its *minimum*, for the two weeks, about the new and full. It is remarkable, that the point of greatest depression during the year, viz. to 28.67, was found about 12 hours after the new moon on the 8th of November; and, that at its greatest and extraordinary elevation to 30.89, on the 7th of February, at the time of the last quarter. Moreover, this coincidence appeared to take place most regularly in fair and moderate weather; and, in general, when the barometer fell, during the interval between the new or full moon and the quarters, an evident perturbation in the atmosphere accompanied; of which may be instanced February 15. to 23. when the barometer, after an uncommon rise, continued to fall rapidly after the new moon, with severe cold, which ended suddenly in stormy and wet weather: again, June 13. to 20. when two weeks of fair weather ended in a thunder storm. In the greater part of December the usual coincidence disappeared, and the converse took place; the barometer being low at the quarter and high at the full, amidst continual alternations of rain, frost, and snow, and, for part of the time, high winds. On the two days preceding the last quarter, the barometer rose rapidly, and rain followed.

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On the whole, Mr Howard thought there appeared sufficient ground, on the evidence of the year 1798, to suppose that the gravity of our atmosphere, as indicated by the barometer, may be subject to certain periodical changes, effected by a cause more steady and regular than either change of temperature, currents, or solution and precipitation of water, to which he believes the whole variation has been heretofore attributed.

The mean of the register at large appeared to be 29.89, whence it appears that the depression at the new and full moon either amounted to more, on the whole, than the elevations at the quarters, or that they fell out nearer to the time. He was quite satisfied, in passing through this register, that if he had allowed himself to choose the higher rotations about the quarters, and the lower about the new and full, with a latitude of 24 or 36 hours, it would have made the results as much more favourable to his conclusions as in the former case.

Now, to omit the consideration of other proofs for the present, it appeared to him evident, that the atmosphere is subject to a periodical change of gravity, whereby the barometer, on a mean of ten years, is depressed at least one-tenth of an inch while the moon is passing from the quarters to the full and new; and elevated, in the same proportion, during the return to the quarter. To what causes shall we attribute this periodical change, other than the attraction of the sun and moon for the matter composing the atmosphere?

The atmosphere is a gravitating fluid, differing, in a physical

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physical sense, from the water, chiefly in possessing less gravity; and it is demonstrated *à priori* on the principles of the Newtonian philosophy, that it ought to have its tides as well as the ocean, although in a degree as much less perceptible as is its gravity.

He supposes, therefore, that the joint attractions of the sun and moon at the new moon, and the attraction of the moon predominating over the sun's weaker attraction at the full, tend to depress the barometer, by taking off from the gravity of the atmosphere, as they produce a high tide in the waters, by taking off from their gravity; and, again, that the attraction of the moon being diminished by that of the sun at her quarters, this diminution tends to make a high barometer, together with a low tide, by permitting each fluid to press with additional gravity upon the earth *.

* *Phil. Mag.* vol. vii. p. 355.

Chap. II. *Of the Changes which take place in the Temperature of the Air.*

It is obvious to the most careless observer, that the temperature of the air varies considerably even in the same place, and at the same season. This constant variation must be attributed to the reflected rays of the sun, which communicate heat from the surface of the earth to the surrounding atmosphere. As from this cause the heat of those places which are so situated as to be most warmed by the sun's rays is always greatest, and as this temperature varies in every place with the season of the year, and diminishes according to the height of the air above the surface; and as the earth at the equator is exposed to the most perpendicular rays of the sun, the earth is there hottest, and its heat diminishes gradually from the equator to the poles. Of course, the temperature of the air must vary in the same manner, being hottest over the equator, and diminishing in temperature towards the poles, where it is coldest. Though it is hottest at the equator, its heat, as in all other situations, gradually diminishes there, as we ascend above the surface of the earth.

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Though there is a considerable difference in every part of the world between the temperature of the atmosphere in summer and in winter; though in the same season the temperature of almost every day, and even every hour, differs from that which precedes and follows it; though the heat varies continually in the most irregular and seemingly capricious manner—still there is a certain mean temperature in every climate, which the atmosphere has always a tendency to observe, and which it neither exceeds nor comes short of beyond a certain number of degrees. What this temperature is, may be known by taking the mean of tables of observations kept for a number of years; and our knowledge of it must be the more accurate the greater the number of observations is.

15 Mean annual temperature greatest at the equator.

The mean annual temperature is greatest at the equator (or at least a degree or two on the north side of it), and it diminishes gradually towards the poles, where it is least. This diminution takes place in arithmetical progression, or, to speak more properly, the annual temperatures of all the latitudes are arithmetical means between the mean annual temperature of the equator and that of the pole. This was first ascertained by Mr Meyer; and Dr Kirwan, improving on Meyer's hint, has calculated in the following table the mean annual temperature of every latitude between the equator and the pole. It must be remarked, however, that this table is calculated only for a particular part of the earth's surface, viz. that part of the Atlantic ocean which lies between the 80° of northern, and the 45° of southern latitude, extending westward as far as the Gulf stream, and to within a few leagues of the coast of America, and for all that part of the Pacific ocean that reaches from 45° of north latitude to 40° of south latitude, and extending between the 20th and 275th degree of longitude east from London. This part of the ocean is called by Dr Kirwan the standard, and was best suited to his purpose, as the rest of the ocean is subject to irregularities, which will be noticed presently (D). See the Article Climate, Supplement.

Lat.	Temper.	Lat.	Temper.	Lat.	Temper.	Lat.	Temper.	Lat.	Temper.	Lat.	Temper.	Lat.	Temper.
90	31.	77	33.7	64	41.2	51	52.4	38	63.9	25	74.5	12	81.7
89	31.04	76	34.1	63	41.9	50	52.9	37	64.8	24	75.4	11	82.0
88	31.10	75	34.5	62	42.7	49	53.8	36	65.7	23	75.9	10	82.3
87	31.14	74	35.0	61	43.5	48	54.7	35	66.6	22	76.5	9	82.7
86	31.2	73	35.5	60	44.3	47	55.6	34	67.4	21	77.2	8	82.9
85	31.4	72	36.0	59	45.09	46	56.4	33	68.3	20	77.8	7	83.2
84	31.5	71	36.6	58	45.8	45	57.5	32	69.1	19	78.3	6	83.4
83	31.7	70	37.2	57	46.7	44	58.4	31	69.9	18	78.9	5	83.6
82	32.0	69	37.8	56	47.5	43	59.4	30	70.7	17	79.4	0	84.0
81	32.2	68	38.4	55	48.4	42	60.3	29	71.5	16	79.9		
80	32.6	67	39.1	54	49.2	41	61.2	28	72.3	15	80.4		
79	32.9	66	39.7	53	50.2	40	62.0	27	72.8	14	80.8		
78	32.2	65	40.4	52	51.1	39	63.0	26	73.8	13	81.3		

Dr

(D) In calculating this table, Dr Kirwan proceeded on the following principle. Let the mean annual heat at the equator be m and at the pole $m-n$; but φ for any other latitude; the mean annual temperature of that latitude will be $m - n \times \sin.\ \varphi^2$. If, therefore, the temperature of any two latitudes be known, the value of m and n may be found. Now, the temperature of north latitude 40° has been found by the best observations to be 62.1°,

and

Dr Kirwan has also calculated in the following table the mean monthly temperature of the same standard (E).

Latit.	80°	79°	78°	77°	76°	75°	74°	73°	72°	71°	70°	69°	68°	67°	66°	65°	64°	63°	62°
Jan.	22.	22.5	23.	23.5	24.	24.5	25.	25.5	26.	26.5	27.	27.5	27.5	28.	28.	28.	29.	30.	31.
Feb.	23.	23.	23.5	24.	24.5	25.	25.5	26.	26.5	27.	27.5	28.	28.	28.5	29.	30.	31.	32.	33.
March	27.	27.5	28.	28.5	29.	29.5	30.	30.5	31.	31.5	32.	32.5	33.	33.5	34.	35.	36.	37.	38.
April	32.6	32.9	33.2	33.7	34.1	34.5	35.	35.5	36.	36.6	37.2	37.8	38.4	39.1	39.7	40.4	41.2	41.9	42.7
May	36.5	36.5	37.	37.5	38.	38.5	39.	39.5	40.	40.5	41.	41.5	42.	42.5	43.	44.	45.	46.	47.
June	51.	51.	51.5	52.	52.	52.	52.5	53.	53.5	54.	54.	54.5	54.5	54.5	55.	55.	55.5	55.5	56.
July	50.	50.	50.5	51.	51.	51.	51.5	52.	52.5	53.	53.5	53.5	53.5	54.	54.5	54.5	55.	55.	55.5
Aug.	39.5	40.	41.	41.5	42.	42.5	43.	43.5	44.	44.5	45.	45.5	46.	47.	48.	48.5	49.	50.	51.
Sept.	33.5	34.	34.5	35.	35.5	36.	36.5	37.	38.	38.5	39.	39.5	40.	41.	42.	43.	44.	45.	46.
Oct.	28.5	29.	29.5	30.	30.5	31.	31.5	32.	32.5	33.	33.5	34.	34.	35.	36.	37.	37.5	38.	39.
Nov.	23.	23.5	24.	24.5	25.	25.5	26.	26.5	27.	27.5	28.	28.5	29.	30.	31.	32.	32.5	33.	34.
Dec.	22.5	23.	23.5	24.	24.5	25.	25.5	26.	26.5	27.	27.5	28.	28.	29.	30.	30.5	31.	31.	32.

Latit.	61°	60°	59°	58°	57°	56°	55°	54°	53°	52°	51°	50°	49°	48°	47°	46°	45°	44°	43°
Jan.	32.	33.	34.	35.	36.	37.	38.	39.	40.	41.	42.	42.5	43.5	43.	42.5	44.	44.5	45.	45.5
Feb.	34.	35.	36.	37.	38.	39.	40.	41.	42.	43.	44.	44.5	44.5	45.	45.5	46.	46.5	47.	48.
March	39.	40.	41.	42.	43.	44.6	45.	46.	48.	49.	50.	50.5	51.	52.5	53.	53.5	54.5	55.5	56.5
April	43.5	44.3	45.09	45.8	46.6	47.5	48.4	49.2	50.2	51.1	52.4	52.9	53.8	54.7	55.6	56.4	57.5	58.4	59.4
May	48.	49.	50.	51.	52.	53.	54.	55.	56.	57.	58.	58.5	59.	60.	61.	62.	63.	64.	65.
June	56.	56.	56.5	57.	57.	57.5	58.	58.5	59.	59.	60.	61.	62.	63.	64.	65.	66.	67.	68.
July	55.5	56.	56.5	57.	57.5	58.	59.	60.	61.	62.	63.	63.5	64.	65.	66.	67.	68.	69.	69.5
Aug.	52.	53.	54.	55.	56.	57.	58.	59.	60.	61.	62.	63.5	64.	65.	66.	67.	68.	69.	69.5
Sept.	47.	48.	49.	50.	51.	52.	53.	54.	55.	56.	57.	58.5	59.	60.	61.	62.	63.	64.	66.
Oct.	40.	41.	42.	43.	44.	45.	46.	47.	48.	49.	50.	50.5	51.	52.	53.	54.	55.	56.	57.
Nov.	35.	36.	37.	38.	39.	40.	41.	42.	43.	44.5	46.	46.5	47.	48.	49.	50.	51.	52.	53.
Dec.	33.	34.	35.	36.	37.	38.	39.	40.	41.	42.	44.	44.5	45.	46.	47.	48.	49.	50.	51.

Latit.	42°	41°	40°	39°	38°	37°	36°	35°	34°	33°	32°	31°	30°	29°	28°	27°	26°	25°	24°
Jan.	46.	46.5	49.5	51.	52.	53.5	55.	56.5	59.5	63.	63.	63.	63.5	63.5	63.5	64.	64.5	65.5	67.
Feb.	49.	50.	53.	56.5	58.	60.	61.	62.	63.	64.5	66.	67.	68.5	68.5	69.5	69.5	70.5	71.	72.
March	58.5	59.5	60.	60.5	61.	62.	63.	64.	65.	66.5	67.5	68.5	69.5	71.	72.	72.5	73.	73.5	74.5
April	60.3	61.2	62.1	63.	63.9	64.8	65.7	66.6	67.4	68.3	69.1	69.9	70.7	71.5	72.3	72.8	73.8	74.5	75.4
May	66.	67.	68.	69.	70.	70.5	71.	71.5	72.	72.5	73.	73.	73.5	74.5	75.5	76.	76.5	77.5	78.
June	69.	70.	70.5	71.	71.	71.	71.5	71.5	72.	72.5	73.	73.	73.5	74.5	75.5	76.	76.5	78.	78.5
July	70.	70.	71.	71.	72.	72.	72.5	72.5	72.5	72.5	73.	73.	73.5	74.5	75.5	76.	76.5	78.	78.5
Aug.	70.	70.	71.	71.	72.	72.	72.5	72.5	72.5	72.5	73.	73.	73.5	74.5	75.5	76.	76.5	78.	78.5
Sept.	68.	69.5	70.5	71.	71.5	72.	72.5	72.5	72.5	72.5	73.	73.	73.5	74.	75.5	76.	76.5	77.5	78.
Oct.	58.	59.	60.	61.	62.	63.	64.	65.	66.	67.5	68.5	69.5	70.5	71.	72.5	72.5	73.	73.5	74.5
Nov.	54.	55.	56.	57.	58.	59.	60.	61.	62.	63.	64.5	64.5	66.5	68.	69.	69.5	71.5	72.	73.5
Dec.	52.	53.	54.	55.	56.	57.	58.	59.	60.	61.	62.5	63.5	64.5	66.	67.	67.5	68.5	69.5	70.

Latit.

and that of latitude 50°, 52.9°. The square of the sine of 40° is nearly 0.419, and the square of the sine of 50° is nearly 0.586. Therefore,

$$m - 0.41\ n = 62.1, \text{ and}$$
$$m - 0.58\ n = 52.9; \text{ therefore,}$$
$$62.1 + 0.41\ n = 52.9 + 058\ n,$$

as each of them, from the two first equations, is equal to m. From this last equation the value of n is found to be nearly 53; and m is nearly equal to 84. The mean temperature of the equator, therefore, is 84°, and that of the pole 31°. To find the mean temperature for every other latitude we have only to find 88 arithmetical means between 84 and 31.

(E) In calculating the table of mean monthly temperature, Dr Kirwan proceeded on the following principles. The mean temperature of April seems to approach very nearly to the mean temperature of the whole year, and as far as heat depends on the action of the solar rays, the mean heat of each month may be considered as propor-

tional

Temperature of the Air.

Latit.	23°	22°	21°	20°	19°	18°	17°	16°	15°	14°	13°	12°	11°	10°
Jan.	68.	69.	71.	72.	72.5	73.	73.5	74.	74.5	75.	76.	76.5	77.	77.5
Feb.	72.	72.5	74.	75.	76.	76.5	77.	77.5	78.	78.5	79.	79.5	79.8	80.
March	75.	75.5	76.	77.	77.5	78.	78.5	79.	79.5	80.	80.8	81.	81.5	81.8
April	75.9	76.5	77.2	77.8	78.3	78.9	79.4	79.9	80.4	80.8	81.3	81.7	82.	82.3
May	78.5	79.5	80.	80.5	81.	81.5	82.	82.5	83.	83.	83.5	84.	84.	84.3
June	79.	79.5	80.	80.5	81.5	82.	82.5	83.	83.5	83.8	84.	84.3	84.6	84.8
July	79.	79.5	80.	80.5	81.5	82.	82.5	83.	83.5	83.8	84.	84.3	84.6	84.8
Aug.	79.	79.5	80.	80.5	81.5	82.	82.5	83.	83.5	83.8	84.	84.3	84.6	84.8
Sept.	78.5	79.	79.5	80.	81.	81.5	82.	82.5	83.	83.	83.5	84.	84.3	84.6
Oct.	75.	75.5	77.	78.	79.	80.	81.	81.5	82.	82.5	83.	83.5	83.8	84.
Nov.	74.	74.5	75.	75.5	76.	77.	78.	78.5	79.	79.5	80.	80.5	80.8	81.
Dec.	71.	71.5	72.	72.5	73.	74.	75.	75.5	76.	76.5	77.	77.5	78.	78.5

Temperature of the Air.

16 It appears from the above table that January is the coldest month in every latitude; that July is the warmest month in all latitudes above 48°; that in lower latitudes August is generally the warmest month; that the difference between the hottest and coldest months increases according to the distance of the place from the equator. All habitable latitudes are found to enjoy a medium heat of 60° for at least 2 months, which is a very favourable circumstance, as probably no corn could be produced under a lower medium temperature. The temperatures within 10° of the poles differ very little, nor do they differ much within 10° of the equator. Hence it was unnecessary to note these latitudes in the table. The temperatures of different years vary but little near the equator, but this difference increases more and more as the latitudes approach the poles.

17 Temperature decreases as we ascend in the air.

It is well known that the temperature of the atmosphere gradually diminishes according to the height of the place above the level of the sea. It was found by Dr Hutton of Edinburgh, that a thermometer kept on the top of Arthur's seat, a height of about 800 feet, usually stood 3° lower than one kept at the foot of this hill; and Bouguer observed that on the top of Pinchincha, a height of about 15564 feet, a thermometer stood 54° lower than it did at the level of the sea in the same latitude.

We are indebted to Dr Kirwan for a very ingenious method of determining the rate of the diminution in the temperature in particular cases, having the temperature of the surface of the earth given. The temperature of the atmosphere constantly diminishing as we rise above the level of the sea, we must at a certain height arrive at a point where a perpetual congelation takes place. This point must vary in height according to the latitude, being highest at the equator, and coming gradually nearer the earth as we approach the poles; it must vary also with the season, being highest in summer, and lowest in winter. The cold on the top of Pinchincha was found by M. Bouguer to extend from 7° to 9° below the freezing point every morning just before sunrise; hence he concluded that between the tropics the medium height of the term of congelation (where it freezes at some part of the day all the year round) should be fixed at 15577 feet above the level of the sea; but in latitude 28°, and during the summer, at 13440 feet. If we take the difference between the temperature at the equator, and the freezing point, this difference will bear the same proportion to the term of congelation at the equator, that the difference between the medium temperature at any other latitude and the freezing point bears to the term of congelation at that latitude. Suppose the medium heat at the equator to be 84°, the difference between which and 32° is 52°; and suppose the medium heat of latitude 28° to be $72\frac{3}{10}$°, the difference between which and 32° is $40\frac{3}{10}$°. Then by the following proportion, $52° : 15577 = 40\frac{3}{10} : 12{,}72°$ gives us the term of congelation at 28°. In this way Dr Kirwan proceeded in calculating the following table.

18 Term of perpetual congelation.

Lat.

tional to the mean altitude of the sun, or rather to the sine of that altitude. If, therefore, we have the mean heat of April, and the sine of the sun's altitude given, the mean heat of May may be found by the following proportion:

As the sine of the sun's mean altitude in April : the mean heat of April = the sine of the sun's mean altitude in May : mean heat of May.

In the same manner the mean heat of June, July, and August may be found; but for the temperature of the succeeding months we must take into consideration another circumstance, since the above rule would make the temperature of these months too low, as it does not take in the heat derived from the earth, which is nearly equal to the mean annual temperature. The real mean heats of these months must be considered as an arithmetical mean between the astronomical and terrestrial heats. Thus, for latitude 51°, the astronomical heat of September being 44.6°, and the mean annual heat 52.4°, the real heat of September ought to be $\frac{44.6+52.4}{2} = 48.5$. Dr Kirwan, however, after going through a tedious calculation, found the results to correspond so little with actual observation, that he drew up the table partly from calculating from principles, and partly from an examination of several sea journals.

Temperature of the Air.

Lat.	Mean height of the term of congelation, in feet.	Lat.	Mean height of the term of congelation, in feet.
0°	15577	45°	7658
5	15457	50	6260
10	15067	55	4912
15	14498	60	3684
20	13719	65	2516
25	13030	70	1557
30	11592	75	748
35	10664	80	120
40	9016		

This last height of 120 feet M. Bouger called the lower term of congelation. He also distinguished another term of congelation above which no visible vapour rises, and this he called the upper term of congelation. This line is considered by Kirwan as much less variable during the summer months than the lower line, and it has therefore been adopted by him to determine the rate of diminution in the temperature as we ascend into the atmosphere. He has calculated its height for every degree of north latitude in the following table.

N. Lat.	Feet.	N. Lat.	Feet.	N. Lat	Feet.	N. Lat	Feet.
0	28000	26	22906	48	12245	70	4413
5	27784	27	22389	49	11750	71	4354
6	27644	28	21872	50	11253	72	4295
7	27504	29	21355	51	10124	73	4236
8	27364	30	20838	52	8965	74	4177
9	27224	31	20492	53	7806	75	4119
10	27084	32	20146	54	6647	76	4067
11	26880	33	19800	55	5617	77	4015
12	26676	34	19454	56	5533	78	3963
13	26472	35	19169	57	5439	79	3911
14	26268	36	18577	58	5345	80	3861
15	26061	37	17985	59	5251	81	3815
16	25781	38	17393	60	5148	82	3769
17	25501	39	16801	61	5068	83	3723
18	25221	40	16207	62	4989	84	3677
19	24941	41	15712	63	4910	85	3631
20	24661	42	15217	64	4831	86	3592
21	24404	43	14722	65	4752	87	3553
22	24147	44	14227	66	4684	88	3514
23	23890	45	13730	67	4616	89	3475
24	23633	46	13235	68	4548	90	3432
25	23423	47	12740	69	4480		(F)

Temperature of the Air.

From the modes of estimating the diminution of temperature now given, which agree extremely well with observation, we find that the temperature diminishes in arithmetical progression, and hence we infer that the temperature of the air at a distance from the earth is owing to the conducting power of the air, and not to the ascent of hot air from the surface of the earth.

19 Temperature of the air above the earth owing to the conducting power of the air.

It is however found that in winter the upper strata of the air are often warmer than the lower; and this superior heat, almost constantly observed in winter, is attributed by Dr Kirwan to a current of warm air from the equator, rolling towards the north pole during our winter *.

We have now given the general method of finding the medium annual temperature all over the globe; but there are several exceptions to our general inferences which must be particularly mentioned.

* Irish Trans. vol. viii. p. 375.

20 Temperature of the North Pacific ocean.

That part of the Pacific ocean which lies between north latitude 52° and 60° is no broader at its northern extremity than 42 miles, and at its southern extremity its breadth scarcely exceeds 1300 miles: it is reasonable to suppose, therefore, that its temperature will be considerably influenced by the surrounding land, which consists of ranges of mountains, covered a great part of the year with snow; and there are besides a great many high, and consequently cold, islands scattered through it. For these reasons Dr Kirwan concludes, that its temperature is at least 4° or 5° below the standard. But we are not yet furnished with a sufficient number of observations to determine this with accuracy.

21 Of the southern hemisphere.

It is the general opinion, that the southern hemisphere beyond the 40° of latitude is considerably colder than the corresponding parts of the northern hemisphere. See America.

22 Of small seas.

Small seas surrounded with land, at least in temperate and cold climates, are generally warmer in summer and colder in winter than the standard ocean, because they are much influenced by the temperature of the land. The gulf of Bothnia, for instance, is for the most part frozen in winter; but in summer it is sometimes heated to 70°, a degree of heat never to be found in the opposite part of the Atlantic. The German sea is above 3° colder in winter, and 5° warmer in summer, than the Atlantic. The Mediterranean sea is, for the greater part of its extent, warmer both in summer and winter than the Atlantic, which therefore flows into it. The Black sea is colder than the Mediterranean, and flows into it.

The eastern parts of North America are much colder than the opposite coast of Europe, and fall short of the standard

(F) Dr Kirwan has given us the following rule for ascertaining the temperature at any required height, supposing we know the temperature of the surface of the earth.

For the temperature observed at the surface of the earth, put m; for the given height h, and t for the height of the upper term of congelation at the given latitude; then $\dfrac{m-32}{\dfrac{t}{100}-1}=$ the diminution of temperature for every 100 feet of elevation; or it is the common difference of the terms of the progression required. Let this common difference thus found be denoted by c; then $c \times \dfrac{h}{100}$ gives us the whole diminution of temperature from the surface of the earth to the given height. Let this diminution be denoted by d, then $m-d$ is obviously the

Temperature of the Air.

standard by about 10° or 12°, as appears from American meteorological tables. The causes of this remarkable difference are many. The highest part of North America lies between 40° and 50° of north latitude, and 100° and 110° of longitude west from London, for there the greatest rivers originate. The very height, therefore, makes this spot colder than it would otherwise be. It is covered with immense forests, and abounds with large swamps and morasses, which render it incapable of receiving any great degree of heat; so that the rigour of winter is much less tempered by the heat of the earth than in the old continent. To the east lie a number of very large lakes, and farther north, Hudson's bay; about 50 miles on the south of which there is a range of mountains which prevent its receiving any heat from that quarter. The bay is bounded on the east by the mountainous country of Labrador and by a number of islands. Hence the coldness of the north-west winds and the lowness of the temperature. But as the cultivated parts of North America are now much warmer than formerly, there is reason to expect that the climate will become still milder when the country is better cleared of woods, though perhaps it will never equal the temperature of the old continent.

23 Of islands.

Islands are warmer than continents in the same degree of latitude; and countries lying to the windward of extensive mountains or forests are warmer than those lying to the leeward. Stones or sand have a less capacity for heat than earth has, which is always somewhat moist; they heat or cool, therefore, more rapidly and to a greater degree. Hence the violent heat of Arabia and Africa, and the intense cold of Terra del Fuego. Living vegetables alter their temperature very slowly, but their evaporation is great; and if they be tall and close, as in forests, they exclude the sun's rays from the earth, and shelter the winter snow from the wind and the sun. Woody countries, therefore, are much colder than those which are cultivated.

We shall conclude this chapter with a series of meteorological axioms respecting the temperature of the air, by M. Cotte.

24 Cotte's axioms respecting temperature.

1. The extreme degrees of heat are almost every where the same; this, however, is not the case in regard to the extreme degrees of cold.

2. The thermometer rises to its extreme height oftener in the temperate zones than in the torrid zone.

3. It changes very little between the tropics; its variations, like those of the barometer, are greater the more one proceeds from the equator towards the poles.

4. It rises higher in the plains than on mountains.

5. It does not fall so much in the neighbourhood of the sea as in inland parts.

6. The wind has no influence on its motions.

7. Moisture has a peculiar influence on it, if followed by a wind which disperses it.

8. The greatest heat, and the greatest cold, take place about six weeks after the northern or southern solstice.

9. The thermometer changes more in summer than in winter.

10. The coldest period of the day is before sunrise.

11. The greatest heat in the sun and the shade seldom takes place on the same day.

12. The heat decreases with far more rapidity from September and October, than it increased from July to September.

13. It is not true, that a very cold winter is the prognostic of a very hot summer.

Chap. III. *Of the Changes which take place in the Air with respect to Evaporation and Rain.*

Evaporation and Rain.

25 Qualities of vapour.

There seems no reason to doubt that water exists in the atmosphere in an intermediate state between that of a fluid and that of absolute steam. This is the state of vapour, of the qualities of which it is proper that we should here take a general view.

We are indebted to the experiments of Saussure and de Luc for much of our knowledge of the qualities of vapour. It is an elastic invisible fluid like common air, but lighter; being to common air, according to Saussure, as 10 to 14, or, according to Kirwan, as 10 to 12; it cannot pass beyond a certain maximum of density, otherwise the particles of water which compose it unite together, and form small, hollow, visible vesicles, called *vesicular vapour;* which is of the same specific gravity with atmospherical air. It is of this vapour that clouds and fogs are composed. This maximum increases with the temperature; and at the heat of boiling water is so great, that steam can resist the whole pressure of the air, and exist in the atmosphere in any quantity.

After what has been stated under Chemistry with respect to the nature and properties of vapour, we have nothing here to add on that subject, except to give the result of observations that have been made on the state of vapour in the atmosphere.

26 Evaporation confined to the surface.

It is found that the evaporation of water into the air is confined entirely to the surface, and hence it is always proportional to the surface exposed to the action of the air. Accordingly, observation shows that in maritime countries, and in marshy situations in the neighbourhood of lakes, rivers, &c. the evaporation is much greater than in inland countries and dry situations.

27 Proportional to the temperature of the air.

It is found that evaporation is greatest in hot weather; whence it must depend, in some degree, on the temperature

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the temperature required. An example will make this rule sufficiently obvious. In latitude 56° the heat below being 54°; required the temperature of the air at the height of 803 feet?

$$\text{Here } m=54,\ t=5533,\ \frac{m-32}{\frac{t}{100}-1}=\frac{22}{54.33}=0404=c, \text{ and } c\times\frac{h}{100}=0.404\times 8.03=3.24=d, \text{ and } m-d=$$

$54-3.24=50.75$. Hence we see that the temperature of the air at the height of 803 feet above the surface is 50°.75.

ture of the air. This was ascertained by Mr Dalton from actual experiments, the result of which was, that the quantity evaporated per minute from a given surface of water at a given temperature, is to the quantity evaporated from the surface at 212°, as the force of vapour at the given temperature is to the force of vapour at 212°. By means of the table expressing the force of vapour at various temperatures given under CHEMISTRY, p. 468, we may discover by the above rule the quantity of water at a given temperature lost by evaporation.

There are several circumstances that affect the quantity of vapour rising from water, even at the same temperature. Thus, we find that evaporation is least in calm weather, increases when there is wind, and is greater in proportion as the wind is stronger. This evidently arises from the agitation of the water, by which a new surface is perpetually exposed to the action of the air.

We shall here insert a table by Mr Dalton, expressing the quantity of vapour raised in various atmospheric temperatures, from a circular surface six inches in diameter.

Temperature.	Force of vapour in inches.	Evaporating force in grains.			Temperature.	Force of vapour in inches.	Evaporating force in grain.		
212°	30	120	154	189	212°	30	120	154	189
20°	.129	.52	.67	.82	53°	.415	1.66	2.13	2.61
21	.134	.54	.69	.85	54	.429	1.71	2.20	2.69
22	.139	.56	.71	.88	55	.443	1.77	2.28	2.78
23	.144	.58	.73	.91	56	.458	1.83	2.35	2.88
24	.150	.60	.77	.94	57	.474	1.90	2.43	2.98
25	.156	.62	.79	.97	58	.490	1.96	2.52	3.08
26	.162	.65	.82	1.02	59	.507	2.03	2.61	3.19
27	.168	.67	.86	1.05	60	.524	2.10	2.70	3.30
28	.174	.70	.90	1.10	61	.542	2.17	2.79	3.41
29	.180	.72	.93	1.13	62	.560	2.24	2.88	3.52
30	.186	.74	.95	1.17	63	.578	2.31	2.97	3.63
31	.193	.77	.99	1.21	64	.597	2.39	3.07	3.76
32	.200	.80	1.03	1.26	65	.616	2.46	3.16	3.87
33	.207	.83	1.07	1.30	66	.635	2.54	3.27	3.99
34	.214	.86	1.11	1.35	67	.655	2.62	3.37	4.12
35	.221	.89	1.14	1.39	68	.676	2.70	3.47	4.24
36	.229	.92	1.18	1.45	69	.698	2.79	3.59	4.38
37	.237	.95	1.22	1.49	70	.721	2.88	3.70	4.53
38	.245	.98	1.26	1.54	71	.745	2.98	3.83	4.68
39	.254	1.02	1.31	1.60	72	.770	3.08	3.96	4.84
40	.263	1.05	1.35	1.65	73	.796	3.18	4.09	5.00
41	.273	1.09	1.40	1.71	74	.823	3.29	4.23	5.17
42	.283	1.13	1.45	1.78	75	.851	3.40	4.37	5.34
43	.294	1.18	1.51	1.85	76	.880	3.52	4.52	5.53
44	.305	1.22	1.57	1.92	77	.910	3.65	4.68	5.72
45	.316	1.26	1.62	1.99	78	.940	3.76	4.83	5.91
46	.327	1.31	1.68	2.06	79	.971	3.88	4.99	6.10
47	.339	1.36	1.75	2.13	80	1.00	4.00	5.14	6.29
48	.351	1.40	1.80	2.20	81	1.04	4.16	5.35	6.54
49	.363	1.45	1.86	2.28	82	1.07	4.28	5.50	6.73
50	.375	1.50	1.92	2.36	83	1.10	4.40	5.66	6.91
51	.388	1.55	1.99	2.44	84	1.14	4.56	5.86	7.17
52	.401	1.60	2.06	2.51	85	1.17	4.68	6.07	7.46

The first column of the above table expresses the temperature; the second, the corresponding force of vapour; the other three columns give the number of grains of water that would be evaporated from a surface of six inches in diameter in the respective temperatures, on the supposition of there being previously no aqueous vapour in the atmosphere. These columns present the extremes and the mean of evaporation likely to be noticed, or nearly such; for the first is calculated upon the supposition of 35 grains loss per minute from the vessel of three inches and a quarter in diameter; the second 45, and the third 55 grains per minute.

As yet we have stated only the degree of evaporation that would take place under various circumstances, provided that the atmosphere were, at the time, entirely free from moisture; but as this can scarcely happen, it becomes necessary to ascertain the rate of evaporation when qualified by the vapour already existing in the atmosphere. This is readily done by first finding the force of the vapour already in the atmosphere, as above directed, and subtracting it from the force of vapour at the given temperature. The remainder is the actual force of evaporation, from which, by the last table, we find the required rate of evaporation.

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tion. Suppose, for instance, it be required to know the rate of evaporation at the temperature of 59°. From the last table we see that the force of vapour at 59° is about 0.5 or $\frac{1}{60}$ its force at 212°. Now, suppose that by trials we find the force of the vapour which already exists in the atmosphere to be 0.25 or $\frac{1}{120}=\frac{1}{2}$ of $\frac{1}{60}$. Subtracting the latter from the former, we have for a remainder 0.25=the force of evaporation required, which is therefore just the half of what it would be if the atmosphere were entirely free from vapour.

The force of vapour existing in the atmosphere is scarcely ever equal to the force of vapour of the temperature of the atmosphere. Hence evaporation may, with a few exceptions, be considered as going on without intermission. Attempts have been made to ascertain the quantity of evaporation that takes place in the course of a year; but the investigation of this problem is so difficult, that these attempts have succeeded only in obtaining approximations towards the truth. Mr Dobson of Liverpool, from a course of experiments made in 1772, 1773, 1774, and 1775, concludes that the mean annual evaporation from the surface of water, amounted to 36.78 inches. The proportions for each month are as follows.

	Inches.		Inches.
January	1.50	July	5.11
February	1.77	August	5.01
March	2.64	September	3.18
April	3.30	October	2.51
May	4.34	November	1.51
June	4.41	December	1.49

The experiments of Mr Dalton shew that the evaporation from the surface of water in a very dry and hot summer day, was rather more than two tenths of an inch.

28 Evaporation from land.

Several experiments have been made on the quantity of evaporation from land, especially by Mr Williams in America, and Dr Watson, Mr Dalton and Mr Hoyle in Britain.

Mr Williams's experiments appear to shew that the evaporation from the surface of such land as is covered with trees and other vegetables is about one-third greater than the evaporation from the surface of water, though much reliance is not laid on these experiments.

From an experiment made by Dr Watson during summer, when the earth had been parched by a month's drought, it appeared that 1600 gallons of water were evaporated from a single acre in 12 hours*. Dr Watson's experiment, however, was of a nature that did not admit of great precision.

29 Experiments by Dalton and Hoyle.

The experiments made by Mr Dalton and Mr Hoyle in the years 1796, 1797, and 1798, are the most exact that have been made on this subject, and we shall therefore consider them more at large. They were made with the following apparatus. Having procured a cylindrical vessel made of tin plate, three feet deep and ten inches in diameter, they inserted into it two pipes directed downwards, so that water might pass through them into two bottles. One pipe was fixed near the bottom of the vessel, and the other about an inch from the top. The vessel was filled up for a few inches with gravel and sand, and all the rest with good fresh soil. It was then put into a hole in the ground, and the space around filled up with earth except on one side, for the convenience of putting bottles to the two pipes; then some water was poured on the earth to sadden it, and all that would drain off was suffered to escape. Hence the earth may be considered as saturated with moisture. The soil was kept for some weeks above the level of the upper pipe, but after that it was constantly allowed to be a little below it, thus preventing any water from running off through that pipe. The top of the soil for the first year was bare; but for the two last years it was covered with grass like other turf. The apparatus being thus prepared, a correct register was kept of the quantity of rain water which ran off from the surface of the earth by the upper pipe, as long as that was below the earth, and also of the quantity of water which passed through the three feet of earth, and ran off by the lower pipe; and a rain gauge of an equal diameter with the cylinder was kept near it, for the purpose of measuring the quantity of rain which fell in any corresponding time. Then, by subtracting the quantity of water which passed through the pipes from that in the rain gauge, the remainder was considered as equal to the quantity evaporated from the surface of the earth in the cylinder. The mean annual result of these experiments is shewn in the following table.

* Watson's *Chemical Essays*, vol. iii. 54.

30 Result.

	Water through the two pipes.			Mean.	Mean Rain.	Mean Evap.
	1796. Inch.	1797. Inch.	1798. Inch.	Inch.	Inch.	Inch.
January	1.897—	.680—	1.774+	1.450+	2.458	1.008
February	1.778—	.918—	1.122	1.273	1.801	.528
March	.431—	.070—	.335	.279	.902	.623
April	.220—	.295—	.180	.232	1.717	1.485
May	2.027—	2.443+	.010	1.493+	4.177	2.684
June	.171—	.726	—	.299	2.483	2.184
July	.153—	.025	—	.059	4.154	4.095
August	—	—	.504	.168	3.554	3.386
September	—	.976	—	.325	3.279	2.954
October	—	.680	—	.227	2.899	2.672
November	—	1.044	1.594	.879	2.934	2.055
December	.200	3.077	1.878+	1.718+	3.202	1.484
	6.877—	10.934—	7.379	8.402	33.560	25.158
Rain	30.629—	38.791—	31.259			
Evap.	23.725—	27.857—	23.862			

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It appears from these experiments, that at Manchester the mean annual evaporation of water is above 25 inches; and if we add to this with Mr Dalton 5 inches for the dew which falls, the whole quantity evaporated in a year will be 30 inches. On the whole, we may perhaps estimate the mean annual evaporation from the whole surface of the globe at 35 inches from every square inch of surface, making the whole water annually evaporated over the whole globe equal to 94.450 cubic miles.

31 Mean annual evaporation over the globe.

Were this prodigious mass of water all to subsist in the atmosphere at once, it would increase its mass by about $\frac{1}{12}$, and raise the barometer nearly 3 inches. But this never happens; no day passes without rain in some part of the earth; so that part of the evaporated water is continually precipitated again. Indeed it would be impossible for the whole of the evaporated water to subsist in the atmosphere at once, at least in the state of vapour.

The higher regions of the atmosphere contain less vapour than the strata near the surface of the earth. This was observed both by M. de Saussure and M. de Luc.

32 At some height above the tops of mountains the atmosphere is probably still drier, for it was observed by Saussure, that on the tops of mountains the moisture of the air was rather less during the night than the day. And there can be little doubt that every stratum of air descends a little lower during the night than it was during the day, owing to the cooling and condensing of the stratum nearest the earth. Vapours, however, must ascend very high, for we see clouds forming far above the tops of the highest mountains.

Rain never begins to fall while the air is transparent; the invisible vapours first pass their maximum, and are changed into vesicular vapours; clouds are formed, and these clouds gradually dissolve in rain. Clouds, however, are not formed in all parts of the horizon at once; the formation begins in one particular spot, while the rest of the air remains clear as before; this cloud rapidly increases till it overspreads the whole horizon, and then the rain begins.

33 Clouds always form at some height.

It is remarkable, that though the greatest quantity of vapour exists in the lower strata of the atmosphere, clouds never begin to form there, but always at some considerable height. It is remarkable, too, that the part of the atmosphere at which they form has not arrived at the point of extreme moisture, nor near that point, even a moment before their formation. They are not formed then because a greater quantity of vapour had got into the atmosphere than could remain there without passing its maximum. It is still more remarkable, that when clouds are formed, the temperature of the spot in which they are formed is not always lowered, though this may sometimes be the case. On the contrary, the heat of the clouds themselves is sometimes greater than that of the surrounding air*. Nor is the formation of clouds owing to the capacity of the air for combining with moisture being lessened by cold; so far from that, we often see clouds which had remained in the atmosphere during the heat of the day, disappear in the night, after the heat of the air was diminished.

* De Luc a Meteorol. vol. ii. 00.

34 The formation of clouds and rain as yet unexplained.

The formation of clouds and rain cannot be accounted for by a single principle with which we are acquainted. It is neither owing to the saturation of the atmosphere, nor the diminution of the heat; nor the mixture of airs of different temperatures, as Dr Hutton supposes: for clouds are often formed without any wind at all either above or below them; and even if this mixture constantly took place, the precipitation, instead of accounting for rain, would be almost imperceptible.

It is a very remarkable fact, that evaporation often goes on for a month together in hot weather without any rain. This sometimes happens in this country; it happens every year in the torrid zone. Thus at Calcutta, during January 1785, it never rained at all; the mean of the thermometer for the whole month was $66\frac{1}{2}°$; there was no high wind, and indeed during great part of the month little wind at all.

The quantity of water evaporated during such a drought must be very great; yet the moisture of the air, instead of being increased, is constantly diminishing, and at last disappears almost entirely. For the dew, which is at first copious, diminishes every night; and if Dr Watson's experiment formerly mentioned be attended to, it will not be objected that the quantity of evaporation is also very much diminished. Of the very dry state to which the atmosphere is reduced during long droughts, the violent thunder-storms with which they often conclude is a very decisive proof. Now what becomes of all this moisture? It is not accumulated in the atmosphere above the country from which it was evaporated, otherwise the whole atmosphere would in a much less period than a month be perfectly saturated with moisture. If it be carried up daily through the different strata of the atmosphere, and wafted to other regions by superior currents of air, how is it possible to account for the different electrical state of the clouds situated between different strata, which often produces the most violent thunder-storms? They could not have remained in the lower strata of the atmosphere, and been daily carried off by winds to other countries; for there are often no winds at all during several days to perform this office; nor in that case would the dews diminish, nor could their presence fail to be indicated by the hygrometer.

It is impossible for us to account for this remarkable fact upon any principle with which we are acquainted. The water can neither remain in the atmosphere, nor pass through it in the state of vapour. It must therefore assume some other form; but what that form is, or how it assumes it, we know not. There are, therefore, two steps of the process which takes place between evaporation and rain, with which we are entirely unacquainted; first, the state of the vapour after it enters into the atmosphere, and second, the cause by which it is made to lay aside the new form which it assumed, return to its state of vapour, and descend in form of rain. Several theories have been contrived to account for this phenomenon, but they are all untenable on the present known laws of chemical action.

The mean annual quantity of rain is greatest at the equator, and decreases gradually as we approach the poles. Thus at Granada, Antilles, 12° N. Lat. it is 126 inches.

Cape François, St Domingo	19°	46′	120
Calcutta - -	22	23	81
Rome - - -	41	54	39
England - -	33	0	32
Petersburgh - -	59	16	16

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On the contrary, the number of rainy days is smallest at the equator, and increases in proportion to the distance from it. From N. Lat. 12° to 43° the mean number of rainy days is 78; from 43° to 46° the mean number is 103; from 46° to 50° it is 134; from 51° to 60°, 161 days.

35 Rainy days often more numerous in winter.

The number of rainy days is often greater in winter than in summer; but the quantity of rain is greater in summer than in winter. At Petersburgh, the number of rainy or snowy days during winter is 84, and the quantity which falls is only about 5 inches; during summer the number of rainy days is nearly the same, but the quantity which falls is about 11 inches.

More rain falls in mountainous countries than in plains. Among the Andes it is said to rain almost perpetually, while in Egypt it scarcely ever rains at all. If a rain-gauge be placed on the ground, and another at some height perpendicularly above it, more rain will be collected into the lower than into the higher; a proof that the quantity of rain increases as it descends, owing perhaps to the drops attracting vapour during their passage through the lower strata of the atmosphere where the greatest quantity resides. This, however, is not always the case, as Mr Copland of Dumfries discovered in the course of his experiments. He observed also, that when the quantity of rain collected in the lower gauge was greatest, the rain commonly continued for some time; and that the greatest quantity was collected in the higher gauge only either at the end of great rains, or during rains which did not last long. These observations are important, and may, if followed out, give us new knowledge of the causes of rain. They seem to shew, that during rain the atmosphere is somehow or other brought into a state which induces it to part with its moisture; and that the rain continues as long as this state continues. Were a sufficient number of observations made on this subject in different places, and were the atmosphere carefully analysed during dry weather, during rain, and immediately after rain, we might soon perhaps discover the true theory of rain.

36 More rain falls in the day than in the night.

Rain falls in all seasons of the year, at all times of the day, and during the night as well as the day; though, according to M. Toaldo, a greater quantity falls during the day than the night. The cause of rain, then, whatever it may be, must be something which operates at all times and seasons. Rain falls also during the continuance of every wind, but oftenest when the wind blows from the south. Falls of rain often happen likewise during perfect calms.

37 Mean annual quantity of rain in Great Britain.

It appears from a paper published by M. Cotte in the *Journal de Physique* for October 1791, containing the mean quantity of rain falling at 147 places, situated between N. Lat. 11° and 60°, deduced from tables kept at these places, that the mean annual quantity of rain falling in all these places in 34.7 inches. Let us suppose then (which cannot be very far from the truth), that the mean annual quantity of rain for the whole is 34 inches. The superficies of the globe consists of 170,981,012 square miles, or 686,401,498,471,475,200 square inches. The quantity of rain, therefore, falling annually will amount to 23,337,650,812,030,156,800 cubic inches, or somewhat more than 91,751 cubic miles of water. This is 16,191 cubic miles of water less than the quantity of water evaporated. It seems probable therefore, if the imperfection of our data warrant any conclusion, that some of the vapour is actually decomposed in the atmosphere, and converted into oxygen and hydrogen gas.

The dry land amounts to 52,745,253 square miles: the quantity of rain falling on it annually therefore will amount to 30,960 cubic miles. The quantity of water running annually into the sea is 13,140 cubic miles; a quantity of water equal to which must be supplied by evaporation from the sea, otherwise the land would soon be completely drained of its moisture.

The quantity of rain falling annually in Great Britain may be seen from the following table:

Years of observation.	Places.	Rain in Inches.
3	Dover - -	37.52
5	Ware, Hertfordshire -	23.6
8	London - -	17.5
8	Kimbolton - -	23.9
45	Lyndon - -	22.21
5	Chatsworth, Derbyshire -	27.865
8	Manchester - -	43.1
18	Liverpool - -	34.41
7	Lancaster - -	40.3
5	Kendal - -	61.223
14	Dumfries - -	36.127
10	Branxholm, 44 miles S. W. of Berwick - -	31.26
5	Langholm - -	36.73
5	Dalkeith - -	25.124
20	Glasgow - -	31.
8	Hawkhill - - -	28.966
	Mean	32.532

Mr Dalton has estimated the quantity of rain that falls in England at 21 inches; but as no account is taken of what falls in Wales and Scotland, this estimate probably falls much short of the real annual quantity. In this country it generally rains less in March than in November, in the proportion at a medium of 7 to 12. It generally rains less in April than October, in the proportion of 1 to 2 nearly at a medium. It generally rains less in May than September; the chances that it does so are at least as 4 to 3: but when it rains plentifully in May, it generally rains but little in September; and when it rains one inch or less in May, it rains plentifully in September.

The degree of moisture that is present in the atmosphere at any given time, is measured by the hygrometer. Under the article HYGROMETER we have amply described several of the most important instruments of that kind; but there is one hygrometer, viz. that of Mr Leslie, which remains to be described in this place. Figures of the instrument are given in Plate CCLXXVI. fig. 13, 14.

The principal part of the instrument is composed of two glass tubes terminated by hollow balls, one transparent and the other opaque. The tubes are selected, as regular as possible, from 4 to 8 inches long, and about $\frac{3}{20}$ of an inch thick, or as slender as those employed for 38 Leslie's hygrometer.

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for thermometers, but with a much wider bore. This, in one tube, must be from $\frac{1}{40}$ to the $\frac{1}{60}$ of an inch in diameter, and an exact calibre, at least not differing by $\frac{1}{50}$ between both its extremities. To the end of it a small piece of black enamel is attached, and blown into an opaque ball, from 4 to $\frac{1}{16}$ of an inch diameter. The corresponding tube may have its bore of the same, or rather a greater width, but its uniformity is not at all essential. Near the extremity it is swelled out into a thin cylinder, almost $\frac{1}{10}$ of an inch wide, and from $\frac{3}{10}$ to $\frac{6}{10}$ long; the inner cavity only being enlarged, without altering the exterior regularity of the tube. The short bit of glass where this cylinder terminates, is now blown into a thin pellucid ball, as nearly of the size of the former as the eye can judge. The exact equality of the balls would be unattainable, and fortunately the theory of the instrument does not require it. When a dark and a bright object are viewed together, the latter, from an optical deception, appears always larger than the reality; and for this reason, says Mr Leslie, I prefer making the clear ball a slight degree smaller than the black one. In the mean time a coloured liquor is prepared by dissolving carmine in concentrated sulphuric acid, in a phial with a ground stopper, taking care to avoid heat, as by this the colouring-matter would be charred, and the beauty of the liquor destroyed.

The tubes are now cut to nearly equal lengths, and the end of each swelled out a little, to facilitate their junction. Close to the black ball, the tube is bent by the flame of a candle into a shoulder, such, that the root of the ball shall come into a line with the inner edge of the tube. This ball, being then warmed, the end of the tube is dipt into the acid liquor, and as much of it allowed to rise and flow into the cavity, as may be guessed sufficient to fill both tubes, excepting the cylinder. The two tubes are then, by the help of a blow-pipe, solidly joined together in one straight piece, without having any knot or protuberance. About half an inch from the joining, and nearer the cylinder, it is gently bent round by the flame of a candle, till the clear ball is brought to touch the tube $\frac{1}{4}$ inch directly below the black one. The instrument is now to be graduated; and the scale chosen by Mr Leslie is that which corresponds to the centigrade thermometer. Mr Leslie thus describes the mode of graduating the instrument.—The instrument is held in an oblique position, that the coloured liquor may collect at the bottom of the black ball, into which a few minute portions of air must, from time to time, be forced over, by heating the opposite ball with the hand. In this way, the interposed liquid will gradually be made to descend into the tube, and assume its proper place; and it should remain for a week or two in an inclined position, to let every particle drain out of the black ball. If any trace of fluid collects in rings within the bore, they are easily dispelled with a little dexterity and manipulation, which, though it would be difficult to describe, is most readily learnt and practised. The small cavity at the joining facilitates the rectification, by affording the means of sending a globule of air in either direction. In fixing the zero of the scale, Mr Leslie set the instrument in a remote corner of the room, or partly closed the window-shutters. When completely adjusted, the top of the coloured liquor, if held upright, should stand nearly opposite to the middle of the cylindrical reservoir.

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In this state of preparation, the instrument is ready for being graduated. The clear ball and the contiguous part of the parallel tube are therefore covered with two or three folds of thin bibulous paper, moistened with pure water, to make it act as a hygrometer; and there is attached to the same tube a temporary scale, by means of a soft cement composed of bees-wax and rosin. A flat round piece of wood being provided with four or five pillars that screw into it, the instrument is fixed to one of them in an erect position, and on each side is disposed a fine corresponding thermometer, inverted, and at the same height, the one having its bulb covered with wet bibulous paper. Then half a yard of flannel is dried as much as possible without singeing, before a good fire, and rolling it up like a sleeve, it is lapped loosely round the lower part of the pillars, and the whole is inclosed under a large bell-glass. The flannel powerfully absorbs moisture from the confined air, and creates an artificial dryness of 80 or 100 degrees. In the space of a quarter or half an hour, the full effect is produced, and the quantities being noted at two or three separate times, the mean results are adopted. The descent, measured by the temporary scale, being then augmented in the proportion of ten to the difference of the two thermometers, will give the length that corresponds to 100°. After the standard instrument is constructed, others are thence graduated with the utmost ease; the first being planted in the centre, and the rest, with their temporary scales, stuck to the encircling pillars. For greater accuracy, the observation should be made in a room without a fire, or a screen ought to be interposed between the fire and the apparatus.

The slips of ivory intended for the scales are divided into equal parts, and should contain from 100° to 150°. The edges are filed down and chamfered, to fit easily between the parallel tubes; and they are secured in their place by a strong solution of isinglass. The lower ball and its annexed cylinder, are covered with thin silk of the same colour as the upper ball, and a few threads are likewise lapped about that part of the tube which it touches. The instrument is lastly cemented into a piece of wood, either end of which admits a cylindrical case that serves equally to protect or to hold it. On other occasions, the hygrometer is inserted into the socket of a round bottom-piece where it stands vertical.

The above description refers particularly to fig. 14. Fig. 13. differs from this, only in having the balls of an equal height, and bended in opposite directions, which Mr Leslie considers as more convenient for some purposes to which the instrument is applied, to be mentioned hereafter, but which renders the instrument less portable.

39 Theory of the instrument.

The action of this hygrometer depends on the following principle; *That the cold produced by evaporation will accurately denote the degree of dryness of the air, or its distance from the point of saturation.* To discover the dryness or humidity of the air, therefore, we have only to find the change of temperature induced in a body of water insulated, or exposed on all sides to evaporation. The steps which led Mr Leslie from these simple

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simple principles to the construction of the present ingenious instrument, are detailed by him in a paper published in Nicholson's Journal for January 1800, to which we must refer our readers for the particulars, contenting ourselves with the following summary view.

If two thermometers be filled with any expansible fluid, and having the bulb of the one wet and the other dry, they will, by their difference, denote the state of the air in respect to humidity. Mr Leslie's object was to combine two such instruments, so that they should indicate merely their difference of temperature; and this object he has completely attained by the present instrument. In ordinary cases, the intermediate liquor would continue stationary; for the air in both balls having the same temperature, and consequently the same elasticity, the opposite pressures would precisely counteract each other; but if, from the action of the external air on the moistened surface, one ball became colder, it is manifest the liquor would be pushed towards it by the superior elasticity of the air included in the other ball, so as to mark, by the space of its approach, the depression of temperature induced by evaporation.

This instrument does not merely point out the dryness of the air; it enables us to determine the *absolute quantity* of moisture which it is capable of imbibing; for the conversion of water into steam is found to consume 524° of the centigrade division; and evaporation, analogous in its effects, may be presumed to occasion the same waste of heat. If, therefore, air had the same capacity as water, for each degree of the hygrometer it would deposit as much heat as it would abstract by dissolving the $\frac{1}{3240}$ part of its weight of humidity. But the capacity of air is to that of water as 11 to six, and consequently it would require in that proportion a greater evaporation to produce the same effect. We may hence conclude, that, for each hygrometric degree, the air would require $\frac{11}{6} \times \frac{1}{3240}$ or $\frac{1}{1858}$ part by weight of water to effect saturation.

Strictly speaking, the degrees marked by this hygrometer do not measure the dryness of the air at its actual temperature, but only its state of dryness when cooled down to the standard of the wet ball. The law, however, being known of the dissolving power of air as affected by heat, it is easy, from the disposition of the air with respect to humidity at one temperature to derive that at any other. It will suffice to mention the result of a number of careful experiments:—Supposing air at the freezing point to be capable of holding 50 parts of moisture; at 10° centigrade, it will hold 100; at 20°, 200; at 30°, 400; thus doubling at each increase of 10°. Hence a table may be constructed by which these conversions will be easily made.

To omit nothing that tends to elucidate the theory of the instrument, we must observe that the air in its contact with the humid surface is not absolutely cooled to the same temperature; the air and water really meet each other at an intermediate point determined by their compounded density and capacity. Consequently the indications of the hygrometer ought to be augmented by the $\frac{1}{464}$ part, or $\frac{11}{6} + \frac{1}{850}$. But this quantity is too small in any case to be regarded. See HYGROMETRY, SUPPLEMENT.

Winds.

CHAP. IV. *Of the Changes produced in the Air by Winds.*

IN considering the subject of winds, we shall first briefly detail their natural history, so far as it has not been already anticipated, and shall then endeavour to trace the laws by which they are regulated, or explain the manner in which their varieties are produced. As the direction of the winds is of the greatest consequence, especially in a commercial view, we shall first point out the direction of the most prevalent winds in various quarters of the world. 40

41 Trade-winds.

Between the tropics the winds are the most regular. In those parts of the Pacific and Atlantic oceans which lie nearest the equator, there is a regular wind during the whole year called the *trade-wind*. On the north side of the equator it blows from the north-east, varying frequently a point or two towards the north or east; and on the south side of it, from the south-east, changing sometimes in the same manner towards the south or east. The space included between the second and fifth degrees of north latitude is the internal limit of these two winds. There the winds can neither be said to blow from the north nor the south; calms and violent storms are frequent. This space varies a little in latitude as the sun approaches either of the tropics. In the Atlantic ocean the trade-winds extend farther north on the American than on the African coast; and as we advance westward, they become gradually more easterly, and decrease in strength. Their force diminishes likewise as we approach their utmost boundaries. It has been remarked also, that as the sun approaches the tropic of cancer, the south-east winds become gradually more southerly, and the north-east winds more easterly: exactly the contrary takes place when the sun is approaching the tropic of capricorn.

42 Monsoons.

The trade-wind blows constantly in the Indian ocean from 10° south latitude to near 30°; but to the northward of this the winds change every six months, and blow directly opposite to their former course. These regular winds are called *monsoons*, from the Malay word *moossin*, which signifies a season. When they shift their direction, variable winds and violent storms succeed, which last for a month, and frequently longer; and during that time it is dangerous for vessels to continue at sea.

The monsoons in the Indian ocean may be reduced to two; one on the north and another on the south side of the equator; which extend from Africa to the longitude of New Holland and the east coast of China, and which suffer partial changes in particular places from the situation and inflection of the neighbouring countries.

Between 3° and 10° of south latitude the south-east trade-wind continues from April to October; but during the rest of the year the wind blows from the north-west. Between Sumatra and New Holland this monsoon blows from the south during our summer months, approaching gradually to the south-east as we advance towards the coast of New Holland; it changes about the end of September, and continues in the opposite direction till April. Between Africa and Madagascar its direction is influenced by the coast; for it blows

Winds. blows from the north-east from October to April, and during the rest of the year from the south-west.

43 Direction of the trade-winds throughout the year. Over all the Indian ocean to the northward of the third degree of south latitude, the north-east trade-wind blows from October to April, and a south-west wind from April to October. From Borneo, along the coast of Malacca and as far as China, this monsoon in summer blows nearly from the south, and in winter from the north by east. Near the coast of Africa, between Mozambique and Cape Guardafeu, the winds are irregular during the whole year, owing to the different monsoons which surround that particular place.—Monsoons are likewise regular in the Red sea; between April and October they blow from the north-west, and during the other months from the south-east, keeping constantly parallel to the coast of Arabia.

44 Of monsoons. Monsoons are not altogether confined to the Indian ocean; on the coast of Brazil, between Cape St Augustine and the island of St Catharine, the wind blows between September and April from the east or north-east, and between April and September from the south-west. The bay of Panama is the only place on the west side of a great continent where the wind shifts regularly at different seasons: there it is easterly between September and March; but between March and September it blows chiefly from the south and south-west.

Such in general is the direction of the winds in the torrid zone all over the Atlantic, Pacific, and Indian oceans; but they are subject to particular exceptions, which we shall now endeavour to enumerate. On the coast of Africa, from Cape Bayador to Cape Verde, the winds are generally north-west; from thence to the island of St Thomas near the equator they blow almost perpendicular to the shore, bending gradually as we advance southwards, first to the west and then to the south-west. On the coast of New Spain likewise, from California to the bay of Panama, the winds blow almost constantly from the west or south-west, except during May, June, and July, when land-winds prevail, called by the Spaniards *Popogayos*. On the coast of Chili and Peru, from 20° to 30° south latitude, to the equator, and on the parallel coast of Africa, the wind blows during the whole year from the south, varying according to the direction of the land towards which it inclines, and extending much farther out to sea on the American than the African coast. The trade-winds are also interrupted sometimes by westerly winds in the bay of Campeachy and the bay of Honduras.

As to the countries between the tropics, we are too little acquainted with them to be able to give a satisfactory history of their winds.

45 Of sea and land breezes. In all maritime countries between the tropics, of any extent, the wind blows during a certain number of hours every day from the sea, and during a certain number towards the sea from the land; these winds are called the *sea and land breezes*. The sea breeze generally sets in about 10 in the forenoon, and blows till six in the evening; at seven the land breeze begins and continues till eight in the morning, when it dies away. During summer the sea breeze is very perceptible on all the coasts of the Mediterranean sea, and even sometimes as far north as Norway.

In the island of St Lewis on the coast of Africa, in 16° north latitude, and 16° west longitude, the wind during the rainy season, which lasts from the middle of July to the middle of October, is generally between the south and the east: during the rest of the year it is for the most part east or north-east in the morning; but as the sun rises, the wind approaches gradually towards the north, till about noon it gets to the west of north, and is called a *sea breeze*. Sometimes it shifts to the east as the sun descends, and continues there during the whole night. In February, March, April, May and June, it blows almost constantly between the north and west. In the island of Bulama, which likewise lies on the west coast of Africa, in 11° north latitude, the wind during nine months of the year blows from the south-west; but in November and December, a very cold wind blows from the north-east.

In the kingdom of Bornou, which lies between 16° and 20° north latitude, the warm season is introduced about the middle of April by sultry winds from the south-east, which bring along with them a deluge of rain. In Fezzan, in 25° north latitude, and 35° east longitude, the wind from May to August blows from the east south-east, or south-west, and is intensely hot.

In Abyssinia the winds generally blow from the west, north-west, north, and north-east. During the months of June, July, August, September and October, the north and north-east winds blow almost constantly, especially in the morning and evening; and during the rest of the year they are much more frequent than any other winds. 46 Winds in Abyssinia.

At Calcutta, in the province of Bengal, the wind blows during January and February from the south-west and south; in March, April, and May from the south; in June, July, August, and September, from the south and south-east; in October, November, and December, from the north-west. At Madras the most frequent winds are the north and north-east.—At Tivoli in St Domingo, and the isles des Vaches, the wind blows oftenest from the south and south-east. From these facts it appears, that in most tropical countries with which we are acquainted, the wind generally blows from the nearest ocean, except during the coldest months, when it blows towards it. 47 At Calcutta.

In the temperate zones the direction of the wind is by no means so regular as between the tropics. Even in the same degree of latitude, we find them often blowing in different directions at the same time, while their changes are often so sudden and capricious, that to account for them has been hitherto found impossible. When winds are violent and continue long, they generally extend over a large tract of country; and this is more certainly the case when they blow from the north-east, than from any other points. By the multiplication and comparison of meteorological tables, some regular connection between the changes of the atmosphere in different places may in time be observed, which will at last lead to a satisfactory theory of the winds. It is from such tables chiefly that the following facts have been collected. 48 In the temperate zones.

In Virginia, the prevailing winds are between the *south-west*, *west*, *north*, and *north-west*; the most frequent is the *south-west*; which blows more constantly in June, July, and August, than at any other season. The north-west winds blow most constantly in Novem- 49 In Virginia.

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Winds.

ber, December, January, and February. At Ipswich in New England, the prevailing winds are also between the south-west, west, north, and north-east; the most frequent is the north-west. But at Cambridge, in the same province, the most frequent wind is the south-east. The predominant winds at New York are the north and west. In Nova Scotia north-west winds blow for three-fourths of the year. The same wind blows most frequently at Montreal in Canada, but at Quebec the wind generally follows the direction of the river St Lawrence, blowing either from the north-east or south-west. At Hudson's bay westerly winds blow for three-fourths of the year; the north-west wind occasions the greatest cold; but the north and north-east are the vehicles of snow.

It appears from these facts, that westerly winds are most frequent over the whole eastern coast of North America; that in the southern provinces south-west winds predominate, and that the north-west become gradually more frequent as we approach the frigid zone.

50 In Egypt.

In Egypt, during part of May, and during June, July, August, and September, the wind blows almost constantly from the *north*, varying sometimes in June to the west, and in July to the west and the east; during part of September, and in October and November, the winds are variable, but blow more regularly from the east than any other quarter; in December, January, and February, they blow from the north, north-west, and west; towards the end of February they change to the south, in which quarter they continue till near the end of March; during the last days of March and in April they blow from the south-east, south, and south-west, and at last from the east; and in this direction they continue during a part of May.

51 In the Mediterranean.

In the Mediterranean the wind blows nearly three-fourths of the year from the north; about the equinoxes there is always an easterly wind in that sea, which is generally more constant in spring than in autumn. These observations do not apply to the gut of Gibraltar, where there are seldom any winds except the east and the west. At Bastia, in the island of Corsica, the prevailing wind is the south-west.

52 In Syria.

In Syria the north wind blows from the autumnal equinox to November; during December, January, and February, the winds blow from the west and south-west; in March they blow from the south, in May from the east, and in June from the north. From this month to the autumnal equinox the wind changes gradually as the sun approaches the equator; first to the east, then to the south, and lastly to the west. At Bagdad the most frequent winds are the south-west and north-west; at Pekin, the north and the south; at Kamtschatka, on the north-east coast of Asia, the prevailing winds blow from the west.

53 In Italy.

In Italy the prevailing winds differ considerably according to the situation of the places where the observations have been made. At Rome and Padua they are northerly, at Milan easterly. All that we have been able to learn respecting Spain and Portugal is, that on the west coast of these countries the west is by far the most common wind, particularly in summer; and that at Madrid the wind is north-east for the greatest part of the summer, blowing almost constantly from the Pyrenean mountains. At Berne in Switzerland, the prevailing winds are the north and west; at St Gothard, the north-east; at Lausanne the north-west and south-west.

54 Result of M Cotte's observations on the direction of the winds in France.

M. Cotte has given us the result of observations made at 86 different places of France, from which it appears, that along the whole south coast of that empire the wind blows most frequently from the north, north-west, and north-east: on the west coast, from the west, south-west, and north-west; and on the north coast from the south-west. That in the interior parts of France the south west wind blows most frequently in 18 places; the west wind in 14; the north in 13; the south in 6: the north-east in 4; the south-east in 2; the east and north-west each of them in one. On the west coast of the Netherlands, as far north as Rotterdam, the prevailing winds are probably the south-west; at least this is the case at Dunkirk and Rotterdam. It is probable also, that along the rest of this coast, from the Hague to Hamburgh, the prevailing winds are the north-west, at least these winds are most frequent at the Hague and at Franeker. The prevailing wind at Delft is the south-east, and at Breda the north and the east.

55 Direction of the winds in Germany.

In Germany the east wind is most frequent at Gottingen, Munich, Weissemburg, Dusseldorff, Saganum, Erford, and at Buda in Hungary; the south-east at Prague and Wirtsburg; the north-east at Ratisbon, and the west at Manheim and Berlin.

56 At London.

From an average of 10 years of the register kept by order of the Royal Society, it appears, that at London the winds blow in the following order:

Winds.	*Days.*	*Winds.*	*Days.*
South-west	112	South-east	32
North-east	58	East	26
North-west	50	South	18
West	53	North	16

It appears from the same register, that the south-west wind blows at an average more frequently than any other wind during every month of the year, and that it blows longest in July and August; that the north-east blows most constantly during January, March, April, May, and June, and most seldom during February, July, September, and December; and that the north-west wind blows oftener from November to March, and more seldom during September and October, than any other months. The south-west winds are also most frequent at Bristol, and next to them are the north-east.

57 Table of winds at Lancaster.

The following table of the winds at Lancaster has been drawn up from a register kept for seven years at that place.

Winds.	*Days.*	*Winds.*	*Days.*
South-west	92	South-east	35
North-east	67	North	30
South	51	North-west	26
West	41	East	17

58 At Dumfries.

The following table is an abstract of nine years observations made at Dumfries by Mr Copland.

Winds.	*Days.*	*Winds.*	*Days.*
South	$82\frac{1}{2}$	North	$36\frac{1}{2}$
West	69	North-west	$25\frac{1}{2}$
East	68	South-east	$18\frac{1}{2}$
South-west	$50\frac{1}{2}$	North-east	$14\frac{1}{2}$

The

Winds.

59 At Cambuslang. The following table is an abstract of seven years observations, made by Dr Meek at Cambuslang, near Glasgow.

Winds.	*Days.*	*Winds.*	*Days.*
South-west	174	North-east	104
North-west	40	South-east	47

It appears from the register from which this table was extracted, that the north-east wind blows much more frequently in April, May, and June, and the south-west in July, August, and September, than at any other period. We learn from the Statistical Account of Scotland, that the south-west is by far the most frequent wind all over that kingdom, especially on the west coast. At Saltcoats in Ayrshire, for instance, it blows three-fourths of the year; and along the whole coast of Murray on the north-east side of Scotland, it blows for two-thirds of the year. East winds are common over all Great Britain during April and May; but their influence is felt most severely on the eastern coast.

The following table exhibits a view of the number of days during which the westerly and easterly winds blow in a year, at different parts of the island. Under the term westerly are included the north-west, west, south-west, and south; the term easterly is taken in the same latitude.

Years of observation.	Places.	Wind. Westerly	Wind. Easterly
10	London	233	132
7	Lancaster	216	149
51	Liverpool	190	175
9	Dumfries	227.5	137.5
10	Branxholm	232	133
7	Cambuslang	214	151
8	Hawkhill near Edin.	229.5	135.5
	Medium	220.3	144.7

60 Direction of the winds in Ireland. In Ireland, the south-west and west are the grand trade-winds, blowing most in summer, autumn, and winter, and least in spring. The north-east blows most in spring, and nearly double to what it does in autumn and winter. The south-west and north-west are nearly equal, and are most frequent after the south-west and west.

61 At Copenhagen, and in Russia. At Copenhagen the prevailing winds are the east and south-east; at Stockholm, the west and north. In Russia, from an average of a register of 16 years, the winds blow from November to April in the following order.

	W.	N.W.	E.	S.W.	S.	NE.	N.	SE.
Days	45	26	23	22	20	19	14	12

And during the other six months,

	W.	N.W.	E.	S.W.	S.	N.E.	N.	S.E.
Days	27	27	19	24	22	15	32	18

The west wind blows during the whole year 72 days; the north-west 53, the south-west and north 46 days each. During summer it is calm for 41 days, and during winter for 21. In Norway the most frequent winds are the south, and south-west and south-east. The wind at Bergen is seldom directly west, but generally south-west or south-east; a north-west, and especially a north-east wind, are but little known there.

From the whole of these facts, it appears that the most frequent winds on the south coasts of Europe are the north, the north-east and north-west, and on the western coast the south-west; that in the interior parts which lie most contiguous to the Atlantic ocean, south-west winds are also most frequent; but that easterly winds prevail in Germany. Westerly winds are also most frequent on the north-east coast of Asia.

It is probable that the winds are more constant in the south temperate zone, which is in a great measure covered with water, than in the north temperate zones, where their direction must be frequently interrupted and altered by mountains and other causes.

M. de la Bailie, who was sent thither by the French king to make astronomical observations, informs us, that at the Cape of Good Hope the main winds are the south-east and north-west; that other winds seldom last longer than a few hours; and that the east and north-east winds blow very seldom. The south-east wind blows in most months of the year, but chiefly from October to April; the north-west prevails during the other six months, bringing along with it rain, and tempests, and hurricanes. Between the Cape of Good Hope and New Holland the winds are commonly westerly, and blow in the following order: north-west, south-west, west, north. 62 Main winds at the Cape of Good Hope.

In the great South sea, from latitude 30° to 40° south, the south-east trade-winds blow most frequently, especially when the sun approaches the tropic of Capricorn; the wind next to it in frequency is the north-west, and next to that is the south-west. 63 In the Pacific ocean.

Thus it appears that the trade-winds sometimes extend farther into the south temperate zone than their usual limits, particularly during summer; that beyond their influence the winds are commonly westerly, and that they blow in the following order: north-west, south-west, west.

We have now considered pretty much at large the direction of the winds in different parts of the earth's surface. Another very curious part of the history of the winds relates to their violence, and the effects with which they are attended, or to the history of hurricanes, whirlwinds, tornadoes, &c. Of some of these we have already treated under the articles Hurricane and Harmattan; and the confined limits of this article oblige us to refer our readers for more particulars to Capper's Observations on the Winds and Monsoons. 64 Theory of the winds.

As to the velocity of the wind, its variations are almost infinite, from the gentlest breeze, to the hurricane which tears up trees and blows down houses. Our most violent winds take place when neither the heat nor the cold is greatest; violent winds generally extend over a large tract of country, and they are accompanied with sudden and great falls in the mercury of the barometer. The wind is sometimes very violent at a distance from the earth, while it is quite calm at its surface. On one occasion Lunardi went at the rate of 70 miles an hour in his balloon, though it was quite calm at Edinburgh when he ascended, and continued so during his whole voyage. 65 Velocity of the winds almost infinitely various.

Winds.

66 Velocity of the winds.

A pretty good idea of the velocity of the wind, under different circumstances, may be formed from the following table, which was drawn up by Mr Smeaton.

Miles per Hour	Feet per Second.	Perpendicular force on one square foot, in Avoirdupois pounds and parts.	
1	1.47	.005	Hardly perceptible.
2	2.93	.020	Just perceptible.
3	4.4	.044	
4	5.87	.079	Gently pleasant.
5	7.33	.123	
10	14.67	.492	Pleasant, brisk.
15	22.	1.107	
20	29.34	1.968	Very brisk.
25	36.67	3.075	
30	44.01	4.429	High wind.
35	51.34	6.027	
40	58.68	7.873	Very high wind.
45	66.01	9.963	
50	73.35	12.300	Storm or tempest.
60	88.02	17.715	Great storm.
80	117.36	31.490	Hurricane.
100	146.7	49.200	Hurricane that tears up trees and carries buildings before it.

For the means of ascertaining the velocity of the winds, see ANEMOMETER and ANEMOSCOPE.

We shall now endeavour to explain the phenomena that we have been describing, or to form a plausible theory of the winds.

The atmosphere is a fluid surrounding the earth, and extending to an unknown height. Now all fluids tend invariably to a level: if a quantity of water be taken out of any part of a vessel, the surrounding water will immediately flow in to supply its place, and the surface will become level as before; or if an additional quantity of water be poured into any part of the vessel, it will not remain there, but diffuse itself equally over the whole. Such exactly would be the case with the atmosphere. Whatever therefore destroys the equilibrium of this fluid, either by increasing or diminishing its bulk in any particular place, must at the same time occasion a wind.

67 Air, besides its qualities in common with other fluids, is also capable of being dilated and compressed. Suppose a vessel filled with air: if half the quantity which it contains be drawn out by means of an air-pump, the remainder will still fill the vessel completely; or if twice or three times the original quantity be forced in by a condenser, the vessel will still be capable of holding it.

Rarefied air is lighter, and condensed air heavier than common air. When fluids of unequal specific gravities are mixed together, the heavier always descend and the lighter ascend. Were quicksilver, water, and oil, thrown into the same vessel together, the quicksilver would uniformly occupy the bottom; the water the middle, and the oil the top. Were water to be thrown into a vessel of oil, it would immediately descend, because it is heavier than oil. Exactly the same thing takes place in the atmosphere. Were a quantity of air, for instance, to be suddenly condensed at a distance from the surface of the earth, being now heavier than before, it would descend till it came to air of its own density; or, were a portion of the atmosphere at the surface of the earth to be suddenly rarefied, being now lighter than the surrounding air, it would immediately ascend.

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68 Cause of the trade-winds.

If a bladder half filled with air be exposed to the heat of the fire, the air within will soon expand, and distend the bladder; if it be now removed to a cold place, it will soon become flaccid as before. This shews that heat rarefies, and that cold condenses air. The surface of the torrid zone is much more heated by the rays of the sun than the frozen or temperate zones, because the rays fall upon it much more perpendicularly. This heat is communicated to the air near the surface of the torrid zone, which being thereby rarefied, ascends, and its place is supplied by colder air, which rushes in from the north and south.

The diurnal motion of the earth is greatest at the equator, and diminishes gradually as we approach the poles, where it ceases altogether. Every spot of the earth's surface at the equator moves at the rate of 15 geographical miles in a minute; at 40° of latitude it moves at about 11 miles and a half in a minute, and at the 30° at nearly 13 miles. The atmosphere, by moving continually round along with the earth, has acquired the same degree of motion, so that those parts of it which are above the equator move faster than those which are at a distance. Were a portion of the atmosphere to be transported in an instant from latitude 30° to the equator, it would not immediately acquire the velocity of the equator; the eminences of the earth, therefore, would strike against it, and it would assume the appearance of an east wind. This is the case in a smaller degree with the air that flows towards the equator, to supply the place of the rarefied air which is continually ascending; and this, when combined with its real motion from north to south, must cause it to assume the appearance of a north-easterly wind on this side the equator, and of a south-easterly beyond it.

The motion westward occasioned by this difference in celerity alone, would be very small; but it is increased by another circumstance. Since the rarefaction of the air in the torrid zone is owing to the heat derived from the contiguous earth, and since this heat is owing to the perpendicular rays of the sun, those parts must be hottest where the sun is actually vertical; and consequently the air above them must be most rarefied; the contiguous parts of the atmosphere will therefore be drawn most forcibly to that particular spot. Now, since the diurnal motion of the earth is from east to west, this hottest spot will be continually shifting westwards, and this will occasion a current of the atmosphere in that direction. That this cause really operates, appears from a circumstance already mentioned: When the sun approaches either of the tropics, the trade-wind on the same side of the equator assumes a more easterly direction, evidently from the cause here mentioned, while the opposite trade-wind being deprived of this additional impulse, blows in a direction more perpendicular to the equator.

69 What increases the westerly direction of the trade-wind.

The westerly direction of the trade-wind is still farther increased by another cause. Since the attraction of the sun and moon produces so remarkable an effect

Winds. effect upon the ocean, we cannot but suppose that an effect equally great, at least, is produced upon the atmosphere. Indeed as the atmosphere is nearer the moon than the sea is, the effects produced by attraction upon it ought to be greater. When we add to this the elasticity of the air, or that disposition which it has to dilate itself when freed from any of its pressure, we cannot but conclude, that the tides in the atmosphere are considerable. Now since the apparent diurnal motion of the moon is from east to west, the tides must follow it in the same manner, and consequently produce a constant motion in the atmosphere from east to west. This reasoning is confirmed by the observations of several philosophers, particularly of M. Casson, that in the torrid zone the barometer is always two-thirds of a line higher twice every 24 hours than during the rest of the day; and that the time of this rise always corresponds with the tides of the sea; a proof that it proceeds from the same cause.

All these different causes probably combine in the production of the trade-winds; and from their being sometimes united, and sometimes distinct or opposite, arise all those little irregularities which take place in the direction and force of the trade-winds.

Since the great cause of these winds is the rarefaction of the atmosphere by the heat of the sun, its ascension and the consequent rushing in of colder air from the north and south, the internal boundary of the trade-winds must be that parallel of the torrid zone which is hottest, because there the ascension of the rarefied air must take place. Now since the sun does not remain stationary, but is constantly shifting from one tropic to the other, we ought naturally to expect that this boundary would vary together with its exciting cause; that therefore, when the sun is perpendicular to the tropic of Cancer, the north-east trade-wind would extend no farther south than north latitude 23° 30′; that the south-east wind would extend as far north; and that, when the sun was in the tropic of Capricorn, the very contrary would take place. We have seen, however, that though this boundary be subject to considerable changes from this very cause, it may in general be considered as fixed between the second and fifth degrees of north latitude.

Though the sun be perpendicular to each of the tropics during part of the year, he is for one-half of it at a considerable distance, so that the heat which they acquire, while he is present, is more than lost during his absence. But the sun is perpendicular to the equator twice in a year, and never farther distant from it than $23\frac{1}{2}$°; being therefore twice every year as much heated, and never so much cooled as the tropics, its mean heat must be greater, and the atmosphere in consequence generally most rarefied at that place. Why then, it will be asked, is not the equator the boundary of the two trade-winds? To speak more accurately than we have hitherto done, the internal limit of these winds must be that parallel where the mean heat of the earth is greatest. This would be the equator, were it not for a reason that shall now be explained.

It has been shewn by astronomers, that the orbit of the earth is an ellipsis, and that the sun is placed in one of the foci. Were this orbit to be divided into two parts by a straight line perpendicular to the transverse axis, and passing through the centre of the sun, one of these parts would be less than the other; and the earth during its passage through the small part of its orbit, would constantly be nearer the sun than while it moved through the other portion. The celerity of the earth's motion in any part of its orbit is always proportioned to its distance from the sun; the nearer it is to the sun it moves the faster; the farther distant, the slower. The earth passes over the smaller portion of its orbit during our winter, which must therefore be shorter than our summer, both on account of this part of the orbit being smaller than the other, and on account of the increased celerity of the earth's motion. The difference, according to Cassini, is 7 days, 23 hours, 53 minutes. While it is winter in the northern, it is summer in the southern hemisphere; wherefore the summer in the southern hemisphere must be just as much shorter than the winter, as our winter is shorter than our summer. The difference, therefore, between the length of the summer in the two hemispheres is almost 16 days. The summer in the northern hemisphere consists of $190\frac{1}{2}$ days, while in the southern it consists only of $174\frac{1}{2}$. They are to one another nearly in the proportion of 14 to 12.8; and the heat of the two hemispheres may probably have nearly the same proportion to one another. The internal limit of the trade-winds ought to be that parallel where the mean heat of the globe is greatest; this would be the equator, if both hemispheres were equally hot; but since the northern hemisphere is the hottest, that parallel ought to be situated somewhere in it; and since the difference between the heat of the two hemispheres is not great, the parallel ought not to be so far distant from the equator.

The trade-wind would blow regularly round the whole globe if the torrid zone were all covered with water. If the Indian ocean were not bounded by land on the north, it would blow there in the same manner as it does in the Atlantic and Pacific oceans. The rays of light pass through a transparent body without communicating any, or at least but a small degree of heat. If a piece of wood be inclosed in a glass vessel, and the focus of a burning-glass directed upon it, the wood will burn to ashes, while the glass through which all the rays passed is not even heated. When an opaque body is exposed to the sun's rays, it is heated in proportion to its opacity. If the bulb of a thermometer be exposed to the sun, the mercury will not rise so high as it would do if this bulb were painted black. Land is much more opaque than water; it becomes therefore much warmer when both are equally exposed to the influence of the sun. For this reason, when the sun approaches the tropic of Cancer, India, China, and the adjacent countries, become much hotter than the ocean which washes their southern coasts. The air over them becomes rarefied, and ascends, while colder air rushes in from the Indian ocean to supply its place. As this current of air moves from the equator northward, it must, for a reason already explained, assume the appearance of a south-west wind; and this tendency eastward is increased by the situation of the countries to which it flows. This is the cause of the south-west monsoon, which blows during summer in the northern parts of the Indian ocean. Between Borneo and the coast of China, its direction is almost due north, because

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cause the country to which the current is directed lies rather to the west of north; a circumstance which counteracts its greater velocity.

In winter, when the sun is on the south side of the equator, these countries become cool, and the north-east trade-wind resumes its course, which, had it not been for the interference of these countries, would have continued the whole year.

As the sun approaches the tropic of Capricorn, it becomes almost perpendicular to New Holland; that continent is heated in its turn, the air over it is rarefied, and colder air rushes in from the north and west to supply its place. This is the cause of the north-west monsoon, which blows from October to April, from 3° to 10° south latitude. Near Sumatra its direction is regulated by the coast: this is the case also between Africa and Madagascar.

The same cause which occasions the monsoons, gives rise to the winds which blow on the west coasts of Africa and America. The air above the land is hotter and rarer, and consequently lighter than the air above the sea; the sea air, therefore, flows in, and forces the lighter land atmosphere to ascend.

The same thing will account for the phenomena of the sea and land breezes. During the day, the cool air of the sea, loaded with vapours, flows in upon the land, and takes the place of the rarefied land air. As the sun declines, the rarefaction of the land air is diminished; thus an equilibrium is restored. As the sea is not so much heated during the day as the land, neither is it so much cooled during the night, because it is constantly exposing a new surface to the atmosphere. As the night approaches, therefore, the cooler and denser air of the hills (for where there are no hills there are no sea and land breezes) falls down upon the plains, and pressing upon the now comparatively lighter air of the sea, causes the land breeze.

The rarefied air which ascends between 2° and 5° north latitude, has been shewn to be the principal cause of the trade-winds. As this air ascends, it must become gradually colder, and consequently heavier; it would therefore descend again if it were not buoyed up by the constant ascent of new rarefied air. It must therefore spread itself to the north and south, and gradually mix in its passage with the lower air; and the greater part of it probably does not reach far beyond 30°, which is the external limit of the trade-wind. Thus there is a constant circulation of the atmosphere in the torrid zone; it ascends near the equator, diffuses itself towards the north and south, descends gradually as it approaches 30°, and, returning again towards the equator, performs the same circuit. It has been the opinion of the greater part of those who have considered this subject, that the whole of the rarefied air which ascends near the equator, advances towards the poles and descends there. But if this were the case, a constant wind would blow from both poles towards the equator, and the trade winds would extend over the whole earth; for otherwise the ascent of air in the torrid zone would very soon cease. A little reflection must convince us that it cannot be true. Rarefied air differs in nothing from the common air, except in containing a greater quantity of heat. As it ascends, it gradually loses this superfluous heat. What then should hinder it from descending, and mixing with the atmosphere below? That there is a constant current of superior air, however, towards the poles, cannot be doubted; but it consists principally of hydrogen gas. We shall immediately attempt to assign the reason why its accumulation at the pole is not always attended with a north wind.

If the attraction of the moon and the diurnal motion of the sun have any effect upon the atmosphere, and that they have some effect can hardly be disputed, there must be a real motion of the air westwards within the limits of the trade-winds. When this body of air reaches America, its further passage westwards is stopt by the mountains which extend from one extremity of that continent to the other. From the momentum of this air, when it strikes against the sides of these mountains, and from its elasticity, it must acquire from them a considerable velocity, in a direction contrary to the first, and would therefore return eastwards again if this were not prevented by the trade-winds. It must therefore rush forwards in that direction where it meets with the least resistance: that is, towards the north and south. As air is nearly a perfectly elastic body, when it strikes against the sides of the American mountains, its velocity will not be perceptibly diminished, though its direction be changed. Continuing to move, therefore, with the velocity of the equator, when it arrives at the temperate zones it will assume the appearance of a north-east or south-east wind. To this is to be ascribed the frequency of south-west winds over the Atlantic ocean and western parts of Europe. Whether these winds are equally frequent in the northern Pacific ocean, we have not been able to ascertain; but it is probable that the mountains in Asia produce the same effect as those in America.

It is not impossible that another circumstance may also contribute to the production of these winds. The oxygen, which is rather heavier than common air, may mix with the atmosphere; but the hydrogen (a cubic foot of which weighs only 41.41 grains, while a cubic foot of oxygen weighs 593.32 grains) may ascend to the higher regions of the atmosphere.

By what means the decomposition is accomplished (if it takes place at all) we cannot tell. There are probably a thousand causes in nature of which we are entirely ignorant. Whether heat and light, when long applied to vapours, may not be able to decompound them, by uniting with the hydrogen, which seems to have a greater attraction for heat than oxygen has, or whether the electrical fluid may not be capable of producing this effect, are questions which future observations and experiments must determine. Dr Franklin filled a glass tube with water, and passed an electrical shock through it; the tube was broken in pieces, and the whole water disappeared. He repeated the experiment with ink instead of water, and placed the tube upon white paper: the same effects followed, and the ink, though it disappeared completely, left no stain on the paper. Whether the water in these cases was decomposed or not, it is impossible to say; but the supposition that it was, is not improbable. An experiment might easily be contrived to determine the point.

This decomposition would account for the frequency of south-west winds, particularly in summer; for this new air is furnished to supply the place of that which is forced northwards by the causes already explained.

Perhaps

Winds. Perhaps it may be a confirmation of this conjecture, that the south-west winds generally extend over a greater tract of country than most other winds which blow in the temperate zones. What has been said of south-west winds holds equally with regard to north-west winds in the south temperate zone.

After south-west winds have blown for some time, a great quantity of air will be accumulated at the pole, at least if they extend over all the northern hemisphere; and it appears, from comparing the tables kept by some of our late navigators in the northern Pacific ocean with similar tables kept in this island, that this is sometimes the case so far as relates to the Atlantic and Pacific oceans. When this accumulation becomes great, it must, from the nature of fluids, and from the elasticity of the air, press with a considerable and increasing force on the advancing air; so that in time it becomes stronger than the south-west wind. This will occasion at first a calm, and afterwards a north wind, which will become gradually easterly as it advances southwards, from its not assuming immediately the velocity of the earth. The mass of the atmosphere will be increased in all those places over which this north-east wind blows; this is confirmed by the almost constant rise of the barometer during a north-east wind.

Whatever tends to increase the bulk of the atmosphere near the pole, must tend also to increase the frequency of north-east winds; and if there be any season when this increase takes place more particularly, that season will be most liable to these winds. During winter the northern parts of Europe are covered with snow, which is melted in the beginning of summer, when the heat of the sun becomes more powerful. Great quantities of vapour are during that time raised, which will augment both the bulk and weight of the atmosphere, especially if the conjecture about the conversion of vapour into air has any foundation. Hence north-east winds are most prevalent during May and June.

But it will be said, if this hypothesis were true, the south-west and north-east winds ought to blow alternately, and continue each of them for a stated time; whereas the south-west wind blows sometimes longer and sometimes shorter, neither is it always followed by a north-east wind.

If the conjecture about the decomposition of vapour in the torrid zone be true, the hydrogen which formed a part of it will ascend from its lightness, and form a stratum above the atmospherical air, and gradually extend itself, as additional hydrogen rises, towards the north and south, till at last it reaches the poles. The lightness of hydrogen is owing to the great quantity of heat which it contains; as it approaches the poles it must lose a great part of this heat, and may in consequence become heavy enough to mix with the atmosphere below. Oxygen makes a part of the atmosphere; and its proportion near the poles may sometimes be greater than ordinary, on account of the additional quantity brought thither from the torrid zone. Mr Cavendish mixed oxygen and hydrogen together in a glass jar; and upon making an electrical spark pass through them, they immediately combined and formed water.

That there is electric matter at the poles, cannot be doubted. The abbé Chappe informs us, that he saw thunder and lightning much more frequently at Tobolski and other parts of Siberia, than in any other part of the world. In the north of Europe, the air, during very cold weather, is exceedingly electric; sparks can be drawn from a person's hands and face, by combing his hair, or even powdering him with a puff. Æpinus was an eye-witness to this fact, and to still more astonishing proofs of the electricity of the atmosphere during great colds.

May not the appearance of the aurora borealis be owing to the union of oxygen and hydrogen by the intervention of the electric fluid? That it is an electrical phenomenon, at least, can hardly be doubted. Artificial electricity is much strengthened during an aurora, as M. Volta and Mr Canton have observed; and the magnetic needle moves with the same irregularity during an aurora that has been observed in other electrical phenomena. This fact we learn from Bergman and De la Lande. Many philosophers have attempted to demonstrate that auroræ boreales are beyond the earth's atmosphere; but the very different results of their calculations evidently prove that they were not possessed of sufficient data.

If this conjecture be true, part of the atmosphere near the poles must at times be converted into water. This would account for the long continuance of south-west winds at particular times; when they do so, a decomposition of the atmosphere is going on at the pole. It would render this conjecture more probable, if the barometer fell always when a south-west wind continues long.

70 South-west winds very common after auroræ boreales.

If this hypothesis be true, a south-west wind ought always to blow after auroræ boreales; and we are informed by Mr Winn, that this is actually the case. This he found never to fail in 23 instances. He observed also, that when the aurora was bright, the gale came on within 24 hours, but did not last long: but if it was faint and dull, the gale was longer in beginning, and less violent, but it continued longer. This looks like a confirmation of our conjecture. Bright auroræ are probably nearer than those which are dull. Now, if the aurora borealis be attended with a decomposition of a quantity of air, that part of the atmosphere which is nearest must first rush in to supply the distant parts. Just as if a hole were bored in the end of a long vessel filled with water, the water nearest the hole would flow out immediately, and it would be some time before the water at the other end of the vessel began to move. The nearer we are to the place of precipitation, the sooner will we feel the south-west wind. It ought therefore to begin sooner after a bright aurora, because it is nearer than a dull and faint one. Precipitations of the atmosphere at a distance from the pole cannot be so great as those which take place near it; because the cold will not be sufficient to condense so great a quantity of hydrogen; south-west winds, therefore, ought not to last so long after bright as after dull auroræ. Winds are more violent after bright auroræ, because they are nearer the place of precipitation; just as the water near the hole of the vessel runs swifter than that which is at a considerable distance.

71 Probable causes of south-west winds.

If these conjectures have any foundation in nature, there are two sources of south-west winds; the first has its origin in the trade winds, the second in precipitations of the atmosphere near the pole. When they originate from the first cause, they will blow in countries farther

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farther south for some time before they are felt in those which are farther north; but the contrary will take place when they are owing to the second cause. In this last case, too, the barometer will sink considerably; and it actually does so constantly after auroræ, as we are informed by Mr Madison, who paid particular attention to this subject. By keeping accurate meteorological tables in different latitudes, it might easily be discovered whether these consequences be true, and of course whether the above conjectures be well or ill grounded.

72 Winds commonly begin at the place towards which they blow.

It appears that winds generally commence at that point towards which they blow; and hence they must arise from a rarefaction and consequent displacing of the air in some particular place, by the action of heat, or some other cause. Perhaps, according to the idea of Mr Williams, this cause may be an increased precipitation of the superior strata of air, rendered unusually dense from its being surcharged with moisture in the place where the wind begins to blow, or from an increased evaporation from a humid surface in the opposite direction.

Hurricanes are constantly preceded by a great depression of the thermometer; and in these cases the wind often seems to blow from every direction towards the quarter where this fall of the barometer is observed.

Violent winds from the north-east have repeatedly been observed to begin at the quarter towards which they blow. In 1740 Dr Franklin was prevented from observing an eclipse of the moon at Philadelphia by a north-east storm, which came on about seven o'clock in the evening. He was surprised to find afterwards that it had not come on at Boston till near 11 o'clock; and, upon comparing all the accounts which he received from the several colonies of the beginning of this and other storms of the same kind, he found it to be always an hour later the farther north-east, for every 100 miles. "From hence (says he) I formed an idea of the course of the storm, which I will explain by a familiar instance. I suppose a long canal of water stopped at the end by a gate. The water is at rest till the gate is opened; then it begins to move out through the gate, and the water next the gate is first in motion, and moves on towards the gate, and so on successively, till the water at the head of the canal is in motion, which it is last of all. In this case the water moves indeed towards the gate; but the successive times of beginning the motion are in the contrary way, viz. from the gate back to the head of the canal. Thus to produce a north-east storm, I suppose some great rarefaction of the air in or near the gulf of Mexico; the air arising thence has its place supplied by the next more northern, cooler, and therefore denser and heavier air; a successive current is formed, to which our coast and inland mountains give a north-east direction."

Several instances of a similar kind have occurred. In 1802, Dr Mitchell observed a storm which began at Charlestown on the 21st of February, at two o'clock P. M. but was not observed at Washington, several hundred miles to the north-east, till five o'clock; at New-York till 10, nor at Albany till daybreak of the following morning. Hence it appears that it must have moved at the rate of 1100 miles in 11 hours, or 100 miles an hour.

A remarkable storm of this kind, in which the wind was easterly, and attended with a heavy fall of snow, was observed in Scotland on the 8th of February 1799; but the motion of the wind was much slower. It began to snow at Falkirk on the 7th of February at six in the evening, but in Edinburgh not till one o'clock A. M. on the 8th; and the snow was not observed at Dunbar till seven hours after. The storm continued 11 hours, during which time it did not travel more than 100 miles.

Currents of air from the poles naturally assume a north-east direction as they advance southwards, because their diurnal motion becomes less than that of the earth. Various circumstances, however, may change this direction, and cause them to become north, or even north-west winds. The south-west winds themselves may often prove sufficient for this; and violent rains, or great heat, by lessening or rarefying the atmosphere in any country, will produce the same effect in countries to the westwards, when north winds happen to be blowing.

In North America, the north-west winds become gradually more frequent as we advance northwards. The east coast of this continent, where the observations were made from which this conclusion was drawn, is alone cultivated; the rest of the country is covered with wood. Now cultivated countries are generally considered as warmer than those which are uncultivated, though Mr Williams is of a different opinion; and on this circumstance founds his hypothesis of the climate of Britain being much deteriorated during the last 50 years. The air, therefore, in the interior parts of the country should be constantly colder than the east coast. This difference will scarcely be perceptible in the southern parts, because there the influence of the sun is very powerful; but it will become gradually greater as we advance northwards, because the influence of the sun diminishes, and the continent becomes broader. Hence north-west winds ought to become more frequent upon the east coast as we advance northwards; and they will probably cease to blow so often as soon as the whole continent of North America becomes cultivated.

73 Different currents often appear in the atmosphere at the same time.

There is one curious circumstance which deserves attention: One current of air is often observed to blow at the surface of the earth, while a current in the contrary direction is flowing in a superior part of the atmosphere. Dr Thomson on one occasion observed three currents of this kind blowing all at the same time in contrary directions. It has been affirmed that changes of weather commonly commence in the upper strata, and that they are gradually extended by the current of air that commences above, proceeding towards the lower parts of the atmosphere.

74 Partial winds.

Besides these more general winds, there are others which extend only over a very small part of the earth. These originate from many different causes. The atmosphere is principally composed of three different kinds of air, oxygen, azote, and carbonic acid, to which may be added water. Great quantities of each of these ingredients are constantly changing their aërial form, and combining with various substances: or they are separating from other bodies, assuming the form of air, and mixing with the atmosphere. Partial deficiencies, therefore, and partial accumulations, must be continually

Meteors. ally taking place in different parts of the atmosphere, which will occasion winds varying in direction, violence, and continuance, according to the suddenness and the quantity of air destroyed or produced. Besides these, there are many other ingredients constantly mixing with the atmosphere, and many partial causes of condensation and rarefaction in particular places. To these, and probably to other causes hitherto unknown, are to be ascribed all those winds which blow in any place besides the general ones already explained; and which, as they depend on causes hitherto at least reckoned contingent, will probably for ever prevent uniformity and regularity in the winds. All these causes, however, may, and probably will, be discovered: the circumstances in which they will take place, and the effects they will produce, may be known; and whenever this is the case, the winds of any place may in some measure be reduced to calculation.

Chap. V. *Of Meteors.*

75 Meteors. THE principal luminous phenomena denominated meteors, have been fully considered under ATMOSPHERIC ELECTRICITY. Those meteors that burst in the air, and are followed by the falling of stones or other mineral substances, have been fully described and accounted for under METEOROLITE. We have here only to notice briefly the meteors called *falling stars*, and *ignes fatui*.

76 Falling star. The falling or shooting star is a very common phenomenon, and takes place more especially at those seasons and in those situations where the aurora borealis is most frequently observed. Indeed they are considered by most philosophers as modifications of the same phenomenon, and depending on the same cause. We have seen good reason to conclude that the aurora borealis is an electrical meteor; and if the falling star is so nearly allied to the aurora as is supposed, it must also be produced by electricity. Mr G. Morgan seems to have no doubt of the electrical nature of this meteor, and remarks that if what appears as an undulating flash in the aurora, could be concentrated or confined within smaller dimensions, it would probably assume the appearance of a falling star. He founds this opinion chiefly on the following experiment.

Into a tube 48 inches long, and $\frac{1}{4}$ inch diameter, Mr Morgan conveyed as much air, as, under the common pressure of the atmosphere, would fill two inches in length of the same tube. (The tube we presume was previously exhausted of air.) One extremity of the tube he connected with the ground by means of good conductors, and fastened to the other a metallic ball. Through the tube thus filled with rarefied air, he sent electric sparks of different magnitudes, by bringing the ball within the striking distance of different fixed conductors. When the sparks were small, a flash like that of the aurora borealis, seemed to fill the whole tube; but when the spark was what might be made to strike through 10 inches in the open air, it appeared to strike through the whole length of the tube, with all the brilliancy and straightness of a falling star. If, however, he extracted part of the air out of the tube, by the air-pump, he could never make the electric fluid assume any form excepting that of a flash; but by exchanging the tube for another with a thermometrical ball, and treating it in the same manner as the preceding, the flash never appeared, but the fluid in its passage assumed all the brilliancy of a falling star.

It is easy to trace the similarity of circumstances that take place in this experiment, and in the natural phenomenon of the falling star. Both take place in rarefied air; both are remarkable for the brightness of their light, and for the straightness of their direction. That falling stars are frequently, if not always, the concentration of an aurora borealis, may be inferred from their being the constant attendants of a very electrical state of the atmosphere; and from their frequent appearance near that portion of the heavens which is illumined by the northern lights at the time of their appearance.

Mr Morgan was riding towards Norwich late at night, when to the north-east of the town he beheld a fine conical stream of the aurora borealis. The whole body every now and then flashed, as if an additional quantity of electric fluid were thrown into it, and nearly at the same instant he perceived what is vulgarly called a falling star, darting from its summit. This appearance he observed twice successively.

The *ignis fatuus*, or *will-with-the-wisp*, that appears so often in boggy, marshy and damp situations, decoying the unwary traveller, and terrifying the superstitious vulgar, seems to be rather of a phosphoric than an electric nature, similar to the light which is emitted by stale fish, rotten wood, and other putrescent substances. Sir Isaac Newton defined it to be a vapour shining without heat. 77 Ignis fatuus.

A remarkable *ignis fatuus* was observed by Mr Derham, in some boggy ground, between two rocky hills. He was so fortunate as to be able to approach it within two or three yards. It moved with a brisk and desultory motion about a dead thistle, till a slight agitation of the air, occasioned, as he supposed, by his near approach to it, occasioned it to jump to another place; and as he approached, it kept flying before him. He was near enough to satisfy himself, that it could not be the shining of glow-worms or other insects—it was one uniform body of light.

M. Beccaria mentions two of these luminous appearances, which were frequently observed in the neighbourhood of Bologna, and which emitted a light equal to that of an ordinary faggot. Their motions were unequal, sometimes rising, and sometimes sinking towards the earth; sometimes totally disappearing, though in general they continued hovering about six feet from the ground. They differed in size and figure; and indeed, the form of each was fluctuating, sometimes floating like waves, and dropping sparks of fire. He was assured there was not a dark night in the whole year in which they did not appear; nor was their appearance at all affected by the weather, whether cold or hot, snow or rain. They have been known to change their colour from red to yellow; and generally grew fainter as any person approached, vanishing entirely when the observer came very near to them, and appearing again at some distance.

Dr Shaw also describes a singular *ignis fatuus*, which he saw in the Holy Land. It was sometimes globular, or in the form of the flame of a candle; and immediately afterwards spread itself so much, as to involve the whole company in a pale inoffensive light, and

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and then was observed to contract itself again, and suddenly disappear. In less than a minute, however, it would become visible as before, and run along from one place to another; or would expand itself over more than three acres of the adjacent mountains. The atmosphere at this time was thick and hazy.

All these luminous appearances are probably owing to the extrication of hydrogen gas so slightly impregnated with phosphorus as to continue emitting a faint light, without producing that brilliant flash which follows the sudden extrication into the air, of the common phosphorated hydrogen gas obtained in the usual chemical experiment of throwing phosphuret of lime into water.

Chap. VI. *Of the Application of Meteorology to Prognosticating the Weather.*

It has ever been a principal object among mankind, to foretel the changes of weather that are likely to follow particular appearances in the sky, among the heavenly bodies, &c.; and it has been often alleged, that in this respect the philosopher is far behind the husbandman and the shepherd. Were the former, however, to add to his scientific researches the observations to which the latter are indebted for their judgment of the weather, he would soon be far superior to them in this respect.

79 Kirwan's conclusions on the weather.

Dr Kirwan has lately endeavoured to discover probable rules for prognosticating the weather in different seasons, as far as regards this climate, from tables of observation alone; and from comparing a number of these observations made in England, from 1677 to 1789, he found,

1. That when there has been no storm before or after the vernal equinox, the ensuing summer is generally *dry*, at least five times in six.

2. That when a storm happens from an easterly point, either on the 19th, 20th, or 21st of May, the succeeding summer is generally *dry* four times in five.

3. That when a storm arises on the 26th, 27th, or 29th of May (and not before), in any point, the succeeding summer is generally *dry* four times in five.

4. If there be a storm at south-west or west-south-west on the 19th, 20th, 21st, or 22d of March, the succeeding summer is generally *wet* five times in six.

In this country winters and springs, if dry, are most commonly cold; if moist, warm: on the contrary, dry summers and autumns are usually *hot*, and moist summers cold. So that if we know the moistness or dryness of a season, we can judge pretty accurately of its temperature.

From a table of the weather kept by Dr Rutty, in Dublin, for 41 years, Dr Kirwan endeavoured to calculate the probabilities of particular seasons being followed by others. Though his rules relate chiefly to the climate of Ireland, yet as probably there is not much difference between that island and Britain, in the general appearance of the seaons, we shall mention his conclusions here.

In 41 years there were six wet springs, 22 dry, and 13 variable; 20 wet summers, 16 dry, and five variable; 11 wet autumns, 11 dry, and 19 variable. A season according to Dr Kirwan, is counted *wet*, when it contains two wet months. In general, the quantity of rain which falls in dry seasons is less than five inches; in wet seasons more. Variable seasons are those in which there falls between 30 and 36 pounds, a pound being equal to .157637 of an inch.

80 Probable succession of seasons.

The order in which the different seasons succeeded each other, was as in the following table.

	Has been followed by a		Times	Probability
A dry spring	dry	Summer	11	$\frac{11}{22}$
	wet		8	$\frac{8}{22}$
	variable		3	$\frac{3}{22}$
A wet spring	dry		0	0
	wet		5	$\frac{5}{6}$
	variable		1	$\frac{1}{6}$
A variable spring	dry		5	$\frac{5}{13}$
	wet		7	$\frac{7}{13}$
	variable		1	$\frac{1}{13}$
A dry summer	dry	Autumn	5	$\frac{5}{10}$
	wet		5	$\frac{5}{16}$
	variable		6	$\frac{6}{16}$
A wet summer	dry		5	$\frac{5}{20}$
	wet		3	$\frac{3}{20}$
	variable		12	$\frac{12}{20}$
A variable summer	dry		1	$\frac{1}{5}$
	wet		3	$\frac{3}{5}$
	variable		1	$\frac{1}{5}$
A dry spring and dry summer	dry		3	$\frac{3}{11}$
	wet		4	$\frac{4}{11}$
	variable		4	$\frac{4}{11}$
A dry spring and wet summer	dry		2	$\frac{2}{8}$
	wet		0	0
	variable		6	$\frac{6}{8}$
A wet spring and dry summer	dry		0	0
	wet		0	0
	variable		0	0
A wet spring and wet summer	dry		2	$\frac{2}{5}$
	wet		1	$\frac{1}{5}$
	variable		2	$\frac{2}{3}$
A wet spring and variable summer	dry		1	$\frac{1}{41}$
	wet		0	0
	variable		0	0
A dry spring and variable summer	dry		0	0
	wet		2	$\frac{2}{3}$
	variable		1	$\frac{1}{3}$
A variable spring and dry summer	dry		2	$\frac{2}{4}$
	wet		0	0
	variable		2	$\frac{2}{4}$
A variable spring and wet summer	dry		1	$\frac{1}{7}$
	wet		1	$\frac{1}{7}$
	variable		5	$\frac{5}{7}$
A variable spring and variable summer	dry		0	0
	wet		1	$\frac{1}{41}$
	variable		0	0

81 Rules for prognosticating the weather.

Hence Dr Kirwan deduced the probability of the kind of seasons which would follow others. This probability is expressed in the last column of the table, and is to be understood in this manner. The probability that

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that a dry summer will follow a dry spring is $\frac{11}{12}$; that a wet summer will follow a dry spring, $\frac{8}{22}$; that a variable summer will follow a dry spring. $\frac{3}{22}$, and so on.

This method of Dr Kirwan, if there is such a connexion between the different seasons that a particular kind of weather in one has a tendency to produce a particular kind of weather in the next, as it is reasonable to expect from theory, may in time, by multiplying observations, come to a great degree of accuracy, and may at last, perhaps, lead to that great desideratum, a rational theory of the weather. As we wish to throw as much light as possible on this important subject, we shall add to these a few maxims, the truth of which has either been confirmed by long observation, or which the knowledge we have already acquired of the causes of the weather has established on tolerably good grounds.

1. A moist autumn with a mild winter is generally followed by a cold and dry spring, which greatly retards vegetation. Such was the year 1741.

2. If the summer be remarkably rainy, it is probable that the ensuing winter will be severe; for the unusual evaporation will have carried off the heat of the earth. Wet summers are generally attended with an unusual quantity of seed on the white thorn and dog-rose bushes. Hence the unusual fruitfulness of these shrubs, is a sign of a severe winter.

3. The appearance of cranes and birds of passage early in autumn announces a very severe winter; for it is a sign it has already begun in the northern countries.

4. When it rains plentifully in May, it will rain but little in September, and *vice versa*.

5. When the wind is south-west during summer or autumn, and the temperature of the air unusually cold for the season, both to the feeling and the thermometer, with a low barometer, much rain is to be expected.

6. Violent temperatures, as storms or great rains, produce a sort of crisis in the atmosphere, which produces a constant temperature, good or bad, for some months.

7. A rainy winter predicts a steril year: a severe autumn announces a windy winter.

82 Signs of rain from birds.

To the above we shall add the following maxims, drawn from observation, and with these shall conclude this article.—Sea and fresh water-fowls, such as cormorants, sea-gulls, muir-hens, &c. flying from sea, or the fresh waters, to land, shew bad weather at hand: land fowls flying to waters, and these shaking, washing, and noisy, especially in the evening, denote the same; geese, ducks, cats, &c. picking, shaking, washing, and noisy; rooks and crows in flocks, and suddenly disappearing; pyes and jays in flocks, and very noisy; the raven or hooded-crow crying in the morning, with an interruption in their notes, or crows being very clamorous at even; the heron, bittern, and swallow flying low; birds forsaking their meat and flying to their nests; poultry going to roost, or pigeons to their dove-house; tame fowls grubbing in the dust, and clapping their wings; small birds seeming to duck and wash in the sand; the late and early crowing of the cock, and clapping his wings; the early singing of wood-larks; the early chirping of sparrows; the early note of the chaffinch near houses; the dull appearance of robin-redbreast near houses; peacocks and owls unusually clamorous.

83 Wind from birds.

Sea and fresh-water fowls gathering in flocks to the banks, and there sporting, especially in the morning; wild-geese flying high, and in flocks, and directing their course eastward; coots restless and clamorous; the hoopoe loud in his note; the king's-fisher taking to land; rooks darting or shooting in the air, or sporting on the banks of fresh waters; and lastly, the appearance of the malefigie at sea, is a certain forerunner of violent winds, and (early in the morning) denotes horrible tempests at hand.

84 Fair weather from birds.

Halcyons, sea-ducks, &c. leaving the land and flocking to the sea; kites, herons, bitterns, and swallows flying high and loud in their notes; lapwings restless and clamorous; sparrows after sunrise restless and noisy; ravens, hawks, and kestrils (in the morning), loud in their notes; robin-redbreast mounted high, and loud in his song; larks soaring high, and loud in their songs; owls hooting with an easy and clear note; bats appearing early in the morning.

85 Rain from beasts.

Asses braying more frequently than usual; hogs playing, scattering their food, or carrying straw in their mouths; oxen snuffing the air, looking to the south, while lying on their sides, or licking their hoofs; cattle gasping for air at noon; calves running violently and gamboling; deer, sheep, or goats, leaping, fighting, or pushing; cats washing their face and ears; dogs eagerly scraping up earth; foxes barking, or wolves howling; moles throwing up earth more than usual; rats and mice more restless than usual; a grumbling noise in the belly of hounds.

86 Rain from insects.

Worms crawling out of the earth in great abundance; spiders falling from their webs; flies dull and restless; ants hastening to their nests; bees hastening home, and keeping close in their hives; frogs and toads drawing nigh to houses; frogs croaking from ditches; toads crying on eminences; gnats stinging more than usual; but, if gnats play in the open air, or if hornets, wasps, and glow-worms appear plentifully in the evening, or if spiders webs are seen in the air, or on the grass, or trees, these do all denote fair and warm weather at hand.

87 Rain from the sun.

Sun rising dim or waterish; rising red with blackish beams mixed along with his rays; rising in a musty or muddy colour; rising red and turning blackish; setting under a thick cloud; setting with a red sky in the east.

N. B. Sudden rains never last long; but when the air grows thick by degrees, and the sun, moon, and stars shine dimmer and dimmer, then it is like to rain six hours usually.

88 Wind from the sun.

Sun rising pale and setting red, with an iris; rising large in surface; rising with a red sky in the north; setting of a bloody colour; setting pale, with one or more dark circles, or accompanied with red streaks; seeming concave or hollow; seeming divided, great storms; parhelia, or mock suns, never appear, but are followed by tempests.

89 Fair weather from the sun.

Sun rising clear, having set clear the night before; rising while the clouds about him are driving to the west; rising with an iris around him; and that iris wearing away equally on all sides, then expect fair and settled weather; rising clear and not hot; setting in red clouds, according to the old observation:

 The

The evening red and morning gray,
Is the sure sign of a fair day.

90 Rain from the moon. Moon pale in colour, rain; horns blunt at first rising, rain; horns blunt, at or within two or three days after the change, denotes rain from that quarter; an iris with a south wind, rain next day; wind south third night after change, rain next day; the wind south, and the moon not seen before the fourth night, rain most of that month; full moon in April, new and full moon in August, for most part bring rain; mock moons are the forerunners of great rains, land floods, and inundations.

91 Wind from the moon. Moon seeming greatly enlarged: appearing of a red colour; horns sharp and blackish; if included with a clear and ruddy iris; if the iris be double or seem to be broken in parts, tempests.

N. B. On the new moon, the wind for the most part changes.

When the moon, at four days old, has her horns sharp, she foretels a tempest at sea, unless she has a circle about her, and that too entire, because, by that she shows that it is not like to be bad weather, till it is full moon.

92 Fair weather from the moon. Moon seeming to exhibit bright spots: a clear iris with full moon; horns sharp fourth day, fair till full; horns blunt at first rising, or within two or three days after change, denotes rain for that quarter; but fair weather the other three quarters. Moon clear three days after change and before full, always denotes fair weather; after every change and full, rains for the most part, succeeded by fair settled weather; moon clear and bright, always fair weather.

93 Weather from the stars. Stars seeming large, dull, and pale of colour, rain; or when their twinkling is not perceptible, or if encompassed with an iris. In summer, when the wind is at east, and stars seem greater than usual, then expect sudden rain, stars appearing great in number, yet clear and bright, seeming to shoot or dart, denote fair weather in summer, and in winter frost.

94 Rain from the clouds. In cloudy weather, when the wind falls, rain follows; clouds growing bigger, or seeming like rocks or towers settling on tops of mountains, coming from the south, or often changing their course; many in number at north-west in the even; being black in colour from the east, rain at night; but out of the west, rain next day; being like fleece of wool, from the east, rain for two or three days; lying like ridges about mid-day in the south-west, shews great storms both of wind and rain to be nigh.

95 Wind from the clouds. Clouds flying to and fro; appearing suddenly from the south or west; appearing red, or accompanied with redness in the air, especially in the morning; being of a leadish colour in the north-west; single clouds denote wind from whence they come; but if at sunset, clouds appear with golden edges, or diminish in bulk, or small clouds sink low, or draw against the wind, or appear small, white, and scattered in the north-west (such as are vulgarly called mackerel) when the sun is high, these are signs of fair weather.

N. B. It is often observed, that though the mackerel sky denotes fair weather for that day, yet for the most part, rain follows in a day or two after.

96 Rain from a rainbow. After a long drought, the rainbow denotes sudden and heavy rains; if green be the predominant colour, it denotes rain, but if red, wind with rain; if the clouds grow darker, rain; if the bow seems broken, violent storms; if appearing at noon, much rain; if in the west great rain, with thunder.

N. B. It is observed, that if the last week in February, and the first fortnight of March, be mostly rainy, and attended with frequent appearances of the bow, a wet spring and summer may be expected.

97 Fair weather from the rainbow. The rainbow appearing after rains, denotes fair weather at hand, if the colours grow lighter, fair; if the bow suddenly disappears, fair; if the bow appear in the morning, it is the sign of small rains, followed by fair weather; and if appearing at night, fair weather; if appearing in the east in the evening, fair; if the bow appear double, it denotes fair weather at present but rain in a few days; if in autumn, it continues fair for two days after the appearance of the aurora borealis, expect fair weather for at least eight days more.

98 Rain from mists. If mists be attracted to the tops of hills then expect rain in a day or two; if, in dry weather, they be observed to ascend more than usual, then expect sudden rain; mists in the new moon foreshew rain in the old; mists also in the old moon denote rain to happen in the new; a misty white scare, in a clear sky in the south-east, is always a forerunner of rain.

99 Fair weather from mists. If mists dissipate quickly, or descend after rain, it is a sure sign of fair weather; a general mist before sun-rising near the full moon, denotes fair weather for about a fortnight running. If after sunset or before sunrise, a white mist arise from the waters and meads, it denotes warm and fair weather next day. A misty dew on the inside of glass windows shows fair weather for that day.

100 Rain from inanimate bodies. Wood swelling, or stones seeming to sweat; lute or viol strings breaking; printed canvas or pasted maps relaxing; salt becoming moist; rivers sinking, or floods suddenly abating; remarkable halo about the candle; great dryness of the earth; pools seeming troubled or muddy; yellow scum on the surface of stagnant waters; dandelion or pimpernel shutting up; trefoil swelling in stalk, while the leaves bow down.

N. B. A dry spring is always attended with a rainy winter.

101 Wind from inanimate bodies. Wind shifting to the opposite point; sea calm, with a murmuring noise; a murmuring noise from the woods and rocks when the air is calm; leaves and feathers seeming much agitated; tides high when the thermometer is high; trembling or flexuous burning of flames; coal burning white with a murmuring noise; thunder in the morning with a clear sky; thunder from the north.

N. B. Whensoever the wind begins to shift, it will not rest till it come to the opposite point; and if the wind be in the north, it will be cold; if in the north-east colder; if in the south; it brings rain; but if in the south-west more rain.

102 Signs of rain ceasing. The sudden closing of gaps in the earth; the remarkable rising of springs or rivers; if the rain begins an hour or two before sunrise it is like to be fair ere noon; but if an hour or two after sunrise, it for the most part happens to continue all day and then to cease; when it begins to rain from the south with a high wind for two or three hours, and that the wind falls, and it still continues raining, it is then like to continue for 12 hours or more, and then to cease.

N. B.

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N. B. These long rains seldom hold above 24 hours, or happen above once a-year.

103 [Signs] of wind ceasing.

A hasty shower after raging winds is a sure sign of the storm being near an end. If the water ruckles and frequent bubbles arise, or if the halcyon or king's-fisher attempts the sea while the storm lasts, or moles come out of their holes, or sparrows chirp merrily, these are all certain signs of the storm ceasing.

Both sea and fresh-water fishes by their frequent rising and fluttering on the surface of the water, foretel the storm nigh over, but especially dolphins spouting up water in a storm foretel a calm.

N. B. Let the wind be in what quarter it will, upon the new moon, it presently changes.

104 [S]igns of [ha]il.

Clouds white, inclining to yellow, and moving heavily though the wind be high, is a sure sign of hail; if the eastern sky before sunrise be pale, and refracted rays appear in thick clouds, then expect great storms of hail: white clouds in summer are a sign of hail, but in winter they denote snow, especially when we perceive the air to be a little warm; in spring or winter, when clouds appear of blueish white, and expand much, expect small hail or drizzling, which properly is no other than frozen mists.

105 [Si]gns of [th]under.

Meteors shooting in the summer's evening, or chops and clefts in the earth, when the weather is sultry, always foretel thunder is nigh; in summer or harvest, when the wind has been south two or three days, and the thermometer high, and clouds rise with great white tops like towers, as if one were upon the top of another, and joined with black on the nether side, expect rain and thunder suddenly; if two such clouds arise, one on either hand, it is then time to look for shelter, as the thunder is very nigh.

N. B. It is observed that it thunders most with a south wind, and least with an east.

106 [Si]gns of [co]ld and [fr]osty wea[th]er.

Sea-pyes, starlings, fieldfares, with other migratory birds appearing early denote a cold season to ensue; the early appearance of small birds in flocks, and of robin-redbreasts near houses; sun in harvest setting in a mist or broader than usual; moon bright, with sharp horns, after change; wind shifting to the east or north after change; sky full of twinkling stars; small clouds hovering low in the north; snow falling small, while clouds appear on heaps like rocks.

N. B. Frosts in autumn are always succeeded with rain.

107 [Si]gns of [th]aw.

Snow falling in large flakes while the wind is at south; cracks appearing in the ice; sun looking waterish; the moon's horns blunted; stars looking dull; wind turning to the south; wind extremely shifting. It is also observed, that, if October and November be frost and snow, January and February are like to be open and mild.

108 Signs of drought.

Fair weather for a week together, while the wind is all that time in the south, is for the most part followed by a great drought; if February be for most rainy, spring and summer quarters are like to be so too; but if it happen to be altogether fair, then expect a drought to follow; if lightning follow after 24 hours of dry and fair weather, drought will follow, but if within 24 hours, expect great rains.

109 Signs of a hard winter.

A moist and cold summer, and mild autumn, are sure signs of a hard and severe winter: store of hips and haws denote the same; the hazel-tree flowering is ever observed to foretel the same; acorns found without any insect is a sure prognostic of a hard winter.

110 Signs of pestilential seasons.

A dry and cold winter with a southerly wind; very rainy spring, sickness in summer; if summer be dry with the wind northerly, great sickness is like to follow; great heats in spring time without winds; roots having a luscious taste, while the wind has been long southerly without rain; and, lastly, great quantities of stinking atoms, insects or animals, as flies, frogs, snakes, locusts, &c.

111 Experiments with the leech.

Inclose the leech worm in an eight ounce phial glass, three-fourths filled with water, covered with a bit of linen; let the water be changed once a-week in summer, and once a fortnight in winter.

If the leech lies motionless at the bottom in a spiral form, fair weather; if crept to the top rain; if restless, wind; if very restless, and without the water, thunder; if in winter at bottom, frost; but if in the winter it pitches its dwelling on the mouth of the phial, snow. See HELMINTHOLOGY (F).

112 Signs of the weather from the barometer.

In calm weather, when the air is inclined to rain, the mercury is low; but when tending to fair, it will rise; in very hot weather when falling, it foreshews thunder; if rising in winter, frost; but if falling in frost, thaw; if rising in a continued frost, snow; if foul weather quickly on its falling, soon over; if fair weather quickly on its rising, soon over; also if rising high in foul weather, and so continuing for two or three days, before the foul weather is over, then expect a continuance of fair weather; but, if in fair weather the mercury fall low, and so continue for two or three days, then expect much rain, and probably high winds.

N. B. In an east wind, the mercury always rises and falls lowest before great winds *.

* *Nicholson's Journal*, Feb. 1804, p. 149.

It was intended to insert in this article a summary view of the opinions of Toaldo, Cotte, and Lamarck, respecting the influence of the moon in producing changes in our atmosphere; but peculiar circumstances render it necessary to postpone this view till we come to the article MOON. See articles, CLIMATE, DEW, HYGROMETRY, METEOROLOGY, in the SUPPLEMENT.

(F) In compliance with the writer of this paper, we have retained this passage on the leech; though, as we stated, when treating of the *Hirudo medicinalis*, in HELMINTHOLOGY, we are very sceptical respecting the *weather-judging* faculties of that worm.

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Meteoromancy || Methodists.

METEOROMANCY, a species of divination by meteors, principally by lightning and thunder. This method of divination passed from the Tuscans to the Romans, with whom, as Seneca informs us, it was held in high esteem.

METESSIB, an officer of the eastern nations, who has the care and oversight of all the public weights and measures, and sees that things are made justly according to them.

METHEGLIN, a species of mead; one of the most pleasant and general drinks which the northern parts of Europe afford, and much used among the ancient inhabitants: (See MEAD). The word is Welsh, *meddyglin*, where it signifies the same.—There are divers ways of making it; one of the best whereof follows: Put as much new honey, naturally running from the comb, into spring water, as that when the honey is thoroughly dissolved an egg will not sink to the bottom, but just be suspended in it; boil this liquor for an hour or more, till such time as the egg swim above the liquor about the breadth of a groat; when very cool, next morning it may be barrelled up; adding to each 15 gallons an ounce of ginger, as much of mace and cloves, and half as much cinnamon, all grossly pounded; a spoonful of yeast may be also added at the bung hole to promote the fermentation. When it has done working, it may be closely stopped up; and after it has stood a month, it should be drawn off into bottles.

METHOD, the arrangement of our ideas in such a regular order, that their mutual connexion and dependence may be readily comprehended. See LOGIC, part iv.

METHODISTS, in ecclesiastical history, is a denomination applied to different sects, both Papists and Protestants.

I. The *Popish Methodists* were those polemical doctors, of whom the most eminent arose in France towards the middle of the 17th century, in opposition to the Huguenots or Protestants. Those Methodists, from their different manner of treating the controversy with their opponents, may be divided into two classes. The one may comprehend those doctors, whose method of disputing with the Protestants was disingenuous and unreasonable, and who followed the examples of those military chiefs, who shut up their troops in intrenchments and strong holds, in order to cover them from the attacks of the enemy. Of this number were the Jesuit Veron, who required the Protestants to prove the tenets of their church by plain passages of scripture, without being allowed the liberty of illustrating those passages, reasoning upon them, or drawing any conclusions from them; Nihusius, an apostate from the Protestant religion; the two Walenburgs, and others, who confined themselves to the business of answering objections and repelling attacks; and Cardinal Richelieu, who confined the whole controversy to the single article of the divine institution and authority of the church. The Methodists of the second class were of opinion, that the most expedient manner of reducing the Protestants to silence, was not to attack them by piecemeal, but to overwhelm them at once, by the weight of some general principle or presumption, some universal argument, which comprehended or might be applied to all the points contested between the two churches: thus imitating the conduct of those military leaders who, instead of spending their time and strength in sieges and skirmishes, endeavoured to put an end to the war by a general and decisive action. These polemics rested the defence of Popery upon prescription; the wicked lives of Protestant princes who had left the church of Rome; the crime of religious schism; the variety of opinions among Protestants with regard to doctrine and discipline;

pline; and the uniformity of the tenets and worship of the church of Rome. To this class belong Nicolle the Jansenist doctor, the famous Bossuet, &c.

II. The *Protestant Methodists* form a very considerable body in this country. The sect was founded in the year 1729 by one Mr Morgan and Mr John Wesley. In the month of November that year, the latter being then fellow of Lincoln college, began to spend some evenings in reading the Greek New Testament, along with Charles Wesley student, Mr Morgan commoner of Christ church, and Mr Kirkham of Merton college. Next year two or three of the pupils of Mr John Wesley, and one pupil of Mr Charles Wesley obtained leave to attend these meetings. Two years after they were joined by Mr Ingham of Queen's college, Mr Broughton of Exeter, and Mr James Hervey; and in 1735 they were joined by the celebrated Mr Whitefield, then in his 18th year.

At this time it is said that the whole kingdom of England was tending fast to infidelity. "It is come (says Bishop Butler), I know not how, to be taken for granted by many persons, that Christianity is not so much as a subject of inquiry, but that it is now at length discovered to be fictitious; and accordingly they treat it as if in the present age this were an agreement among all people of discernment, and nothing remained but to set it up as a principal subject of mirth and ridicule, as it were by way of reprisals, for its having so long interrupted the pleasures of the world." The Methodists are said, with great probability, to have been very instrumental in stemming this torrent. They obtained their name from the exact regularity of their lives; which gave occasion to a young gentleman of Christ church to say, "Here is a new set of *Methodists* sprung up;" alluding to a sect of ancient physicians which went by that name. This extreme regularity, however, soon brought a charge against them, perhaps not altogether without foundation, of being too scrupulous, and carrying their sanctity to too great a height. In particular it was urged, that they laid too much stress upon the rubrics and canons of the church, insisted too much on observing the rules of the university, and took the scriptures in too literal a sense; and to the name of *Methodists* two others were quickly added, viz. those of *Sacramentarians* and the *Godly Club*.

The principal person in this club while in its infancy appears to have been Mr Morgan, and next to him Mr John Wesley. They visited the sick, and instituted a fund for the relief of the poor; and the better to accomplish their benevolent designs, Mr Wesley abridged himself of all his superfluities, and even of some of the necessaries of life; and by proposing the scheme to some gentlemen, they quickly increased their funds to 80l. *per annum*. This, which one should have thought would have been attended with praise instead of censure, quickly drew upon them a kind of persecution; some of the seniors of the university began to interfere, and it was reported "that the college censors were going to blow up the Godly Club *." They found themselves, however, patronised and encouraged by some men eminent for their learning and virtue; so that the society still continued, though they had suffered a severe loss in 1730 in the death of Mr Morgan, who had indeed been the founder of it. In the month of October 1735, John and Charles Wesley, Mr Ingham, and Mr Delamotte son to a merchant in London, embarked for Georgia along with Mr Oglethorpe, afterwards General Oglethorpe. The design of this voyage was to preach the gospel to the Indians. By this time, however, it appears that Mr Wesley had embraced such notions as may without the least breach of charity be accounted fanatical. Thus in a letter to his brother Samuel, he conjures him to banish from his school "the classics with their poison," and to introduce instead of them such Christian authors as would work together with him in "building up his flock in the knowledge and love of God."

* See *Wesley's Life*, p. 105.

During the voyage such a profusion of worship was observed, as we cannot help thinking savoured more of a Pharisaical than Christian behaviour; an account of which, as a similar strictness would certainly be inculcated upon the disciples, and consequently must give a just idea of the principles of the early Methodists, we shall here transcribe from Mr Wesley's life. "From four in the morning till five, each of us used private prayer; from five to seven we read the Bible together, carefully comparing it (that we might not lean to our own understandings) with the writings of the earliest ages; at seven we breakfasted; at eight were the public prayers; from nine to twelve learned the languages and instructed the children; at twelve we met to give an account to one another what we had done since our last meeting, and what we designed to do before our next; at one we dined; the time from dinner to four we spent in reading to those of whom each of us had taken charge, or in speaking to them separately as need required; at four were the evening prayers, when either the second lesson was explained (as it always was in the morning), or the children were catechised and instructed before the congregation; from five to six we again used private prayer; from six to seven I read in our cabin to two or three of the passengers, of whom there were about 80 English on board, and each of my brethern to a few more in theirs; at seven I joined with the Germans in their public service, while Mr Ingham was reading between decks to as many as desired to hear; at eight we met again, to instruct and exhort one another; between nine and ten we went to bed, when neither the roaring of the sea nor the motion of the ship could take away the refreshing sleep which God gave us."

As they proceeded in their passage, this austerity instead of being diminished was increased. Mr Wesley discontinued the use of wine and flesh; confining himself to vegetables, chiefly rice and biscuit. He ate no supper; and his bed having been made wet by the sea, he lay upon the floor, and slept soundly till morning. In his Journal he says, "I believe I shall not find it needful to go to bed, *as it is called*, any more;" but whether this was really done or not, we cannot say.

The missionaries, after their arrival, were at first very favourably received, but in a short time lost the affections of the people entirely. This was owing to the behaviour of Mr Wesley himself, who appeared not only capricious but frequently despotic. He particularly gave offence by insisting upon the baptism of children by immersion; and his excessive austerity with regard to himself

 himself did not tend to give his hearers any favourable opinion either of the superior sanctity or wisdom of their teacher. At last, on account of a difference with Mr Causton the storekeeper and chief magistrate of Savannah which ended in a law-suit, he was obliged to return to England.

Thus the cause of Methodism seemed to be entirely lost in Georgia. But Mr Wesley was soon succeeded by a more popular and successful champion, viz. Mr George Whitefield; who having spent his time during the voyage in converting the soldiers with whom he sailed, arrived at Savannah in Georgia on the 7th of May 1738. Here he was received by Mr Delamotte, was joined by several of Mr Wesley's hearers, and became intimate with some other ministers. Mr Ingham had made some progress in converting a few runaway Creek Indians, who had a settlement about four miles from Savannah; but being obliged to return to England in a few months, this design was frustrated, and the Indians in a few years separated. During the short time that Mr Whitefield resided at Savannah, he became extremely popular; and indeed the instances of his success in the way of making converts are very surprising. However, he was obliged to return to England in the autumn of that year, that he might receive priests orders. On his return to America in October 1739, he landed at Philadelphia, and instantly began his spiritual labours as in other places; being attended with astonishing success not only there but wherever he went. Passing through the colonies of Virginia, Maryland, North and South Carolina, the number of converts continually increased; but on his arrival at Savannah, he found the colony almost deserted. He now resumed the scheme he had formerly projected of building an Orphan-house; and for this he made the first collection at Charlestown in South Carolina, amounting to about 70l. sterling. His zeal in the cause of religion, or of the colony, were not, however, sufficient to procure him the favour of those in power. On his return to Philadelphia, after a short stay at Savannah, the churches were denied him; but he was made ample amends by the success which attended his field preachings and private efforts. Religious societies were everywhere set up, and many were converted with symptoms of enthusiasm, different according to their various tempers and constitutions. During this excursion, he was so successful in his collection for the Orphan-house, that on his return to Savannah he brought along with him money and provisions to the value of 500l. sterling.

The success in Georgia was now greater than ever; but the many charities which it was necessary to supply, rendered it necessary in a short time for him to undertake another journey to Charlestown. Here his principles met with the greatest opposition. He had lost the favour of the commissary by his field-preaching, and was denied the sacrament. The opposition, however, was altogether fruitless; the number of converts increased wherever he went, and he now undertook a voyage to New England. In this place also the established clergy were his enemies; but the usual success attended his other endeavours, and procured 500l. more for the use of the Orphans in Georgia.

From the year 1741 to 1743 America was deprived of Mr Whitefield's preaching, he having spent that interval in England; but in 1744 he again set out for the western continent. The remarkable success which had hitherto attended his labours now stirred up many opponents; and these had met with the greater success, as none of the Methodist preachers whom he had left were possessed of such abilities either to gain the favour of those who heard them, or to defend their doctrines against objections. Mr Whitefield's sucess, however, was the same as before: he even found means to inspire the military class with such sentiments of devotion, that Colonel Pepperell could not undertake his expedition against Louisbourg without first consulting Mr Whitefield; and great numbers of New-Englanders went volunteers, confident of victory, in consequence of the discourses of their teacher.

From the continent of America Mr Whitefield took a voyage to the Bermudas islands; and here, as everywhere else, he met with the most surprising success. Here also collections were made for the Orphan-house in Savannah, which were transmitted to that place.

Supposing it to be better for his cause to visit different countries, than to take up a permanent residence in one, Mr Whitefield left Bermudas in a few months, and did not return to America till 1751, when the Orphan-house was found to be in a very flourishing situation. After a short stay, he set sail again for Britain. Here he remained two years, and then set out on another visit to America, landing at Charlestown on the 27th of May 1754. His presence constantly revived the spirits and cause of his party, and added to their numbers wherever he went. Next year he returned to England; but after labouring in the usual manner, and meeting with the usual success there till the year 1763, he set sail again for America, and arrived at Virginia in the latter end of August. He now visited all the colonies, and found that great progress had been made in converting the Indians. On his arrival at Georgia, matters were found in a very flourishing situation, and he received the thanks of the governor and principal people for the great benefit he had been to the colony; which shows, that the stories which had been so industriously propagated, concerning the avarice of him and other Methodist preachers, were, partly at least, unfounded. In 1765 he returned to England; and in 1769 made his seventh and last voyage to America, landing at Charlestown on the 30th of November the same year. He was still attended with the same success; and indeed it is impossible to read, without admiration, an account of the efforts made by himself and Mr Wesley, to propagate their tenets in the different parts of the world.

For a very considerable time Mr Whitefield was the only Methodist who paid any attention to America; and in that country he was more popular than even in Europe. Towards the end of his life, several Methodists having emigrated from Britain, formed distinct societies in New York and Philadelphia. These quickly increased in number; and, about the time that the war with Britain began, their numbers amounted to about 3000 in Virginia, Maryland, New York, and Pennsylvania. They would probably have increased much more, had it not been for the imprudence of some of their preachers, who introduced

troduced politics into their discourses, and thus rendered themselves obnoxious to the people among whom they lived. Among those who hurt the cause in this manner was Mr Wesley himself, who, by writing a piece entitled *A Calm Address to the American Colonies*, would in all probability have ruined it, had not a gentleman, with whom he was connected, destroyed or sent back to England the whole impression as soon as it arrived in America, so that its existence was scarce known in that continent. At the conclusion of the war, Dr Coke, who in 1776 had left a curacy in England in order to join Mr Wesley, paid a visit to his friends in America; though it had been imagined that a total separation had taken place between the American and European Methodists. This breach was, however, made up by a manœuvre of Mr Wesley; for no sooner had the Americans obtained their independence, than he, who had hitherto branded them with the name of *rebels*, sent a congratulatory letter on their freedom from the "State and the Hierarchy," and exhorting them to "stand fast in that liberty with which God had so strangely made them free." To show his zeal in their service still farther, he gave ordination, by laying on of hands, to several preachers who were to embark for America, and consecrated Dr Coke one of the bishops of the Methodist Episcopal church in that country. He extracted also from the liturgy of the English church one for the American Methodists, taking particular care to expunge every expression that had a particular respect to the regal authority.

Such proceedings in one who had formerly professed such extraordinary attachment to the English church, could not but require an apology; and this was accordingly made in a pastoral letter transmitted to the American societies, and addressed "to Dr Coke, Mr Astbury, and our brethren in North America." In this letter he makes the following defence of his conduct. "Lord King's account of the primitive church convinced me, many years ago, that bishops and presbyters are the same order, and consequently have the same right to ordain. For many years I have been importuned, from time to time, to exercise this right, by ordaining part of our travelling preachers. But I have still refused, not only for the sake of peace, but because I was determined, as little as possible, to violate the established order of the national church to which I belonged. But the case is widely different between England and North America. Here there are bishops who have a legal jurisdiction: in America there are none, neither any parish ministers: so that for some hundred miles together, there is none either to baptize, or to administer the Lord's supper. Here, therefore, my scruples are at an end; and I conceive myself at full liberty, as I violate no order, and invade no man's right, by appointing and sending labourers into the harvest. It has indeed been proposed to desire the English bishops to ordain part of our preachers for America; but to this I object. 1. I desired the bishop of London to ordain only one, but could not prevail. 2. If they consented, we know the slowness of their proceedings; but the matter admits of no delay. 3. If they would ordain them now, they would likewise expect to govern them; and how grievously would that entangle us. 4. As our American brethren are now totally disentangled, both from the state and the English hierarchy, we dare not entangle them again either with the one or the other. They are now at full liberty simply to follow the scripture and the primitive church; and we judge it best, that they should stand fast in that liberty wherewith God has so strangely made them free."

Dr Coke, on the consecration of Mr Astbury to the office of a bishop, made another apology. "The church of England (says he), of which the society of Methodists in general have till lately professed themselves a part, did for many years groan in America under grievances of the heaviest kind. Subjected to a hierarchy which weighs every thing in the scale of politics, its most important interests were repeatedly sacrificed to the supposed advantages of England. The churches were in general filled with the parasites and bottle-companions of the rich and great. The humble and most importunate entreaties of the oppressed flocks, yea the representations of a general assembly itself, were contemned and despised. Every thing sacred must bow down at the feet of a party; the holiness and happiness of mankind be sacrificed to their views; and the drunkard, the fornicator, and the extortioner, triumphed over bleeding Zion, because they were faithful abettors of the ruling powers. The memorable revolution has struck off these intolerable fetters, and broken the antichristian union which before subsisted between church and state. And had there been no other advantage arising from that glorious epoch, this itself, I believe, would have made ample compensation for all the calamities of the war; one happy consequence of which was the expulsion of most of those hirelings, who "ate the fat, and clothed themselves with the wool, but strengthened not the diseased," &c. The parochial churches in general being hereby vacant, our people were deprived of the sacraments through the greatest part of these states, and continue so still. What method can we take in so critical a juncture? God has given us sufficient resources in ourselves; and, after mature deliberation, we believe that we are called to draw them forth.

"But what right have you to ordain?" The same right as most of the churches in Christendom; our ordination, in its lowest view, being equal to any of the presbyterian, as originating with three presbyters of the church of England. "But what right have you to exercise the episcopal office?" To me the most manifest and clear. God has been pleased to raise up, by Mr Wesley, in America and Europe, a numerous society well known by the name of *Methodists*. The whole body have invariably esteemed this man as their chief pastor under Christ. He has constantly appointed all their religious officers from the highest to the lowest, by himself or his delegate. And we are fully persuaded there is no church office which he judges expedient for the welfare of the people entrusted to his charge, but, as essential to his station, he has power to ordain. "But, do not you break the succession?" The uninterrupted succession of bishops is a point that has long been given up by the most able Protestant defenders of episcopacy. Bishop Hoadley himself, in his celebrated controversy with Dr Calamy, allows it to be unnecessary. His words are, 'To the 13th question I answer, that I think not an uninterrupted line of succession

cession of regularly ordained bishops necessary.' He also grants the authenticity of the anecdote given us by St Jerome, which informs us, that the church of Alexandria had no regular succession from the time of St Mark the evangelist, the first bishop of that church, to the time of Dionysius, a space of 200 years; but the college of presbyters, on the death of a bishop, elected another in his stead. We are also informed, from the epistle of St Clement to the Corinthians, written soon after the death of St Paul, a writer whose works are next in precedence to the canon of scripture, and probably written by immediate inspiration, that the church of Corinth was then governed only by a college of presbyters. And from the epistle of Polycarp to the church of Philippi, written in 116, we also find that the Christian Philippians were then governed only by a college of presbyters. So that the primitive Christians were so far from esteeming the regular succession as essential to the constitution of a Christian church, that, in some instances, episcopacy itself was wholly omitted.

Such was the defence urged by Mr Wesley for this extraordinary assumption of episcopal powers: a conduct, however, of which he afterwards repented, as tending to make a final separation betwixt his followers and the church of England. Yet it does not appear that this had any bad effect on the minds of his American brethren; for Dr Coke, on his arrival on the western continent, found the societies numerous and flourishing. His first efforts were directed against the slave trade; and not only the abolition of that traffic, but the release of all those who were actually slaves at the time, seem to have been his favourite objects. By interfering in this matter, however, perhaps with too much zeal, he involved himself in danger. Some riots took place, and a lady offered the mob 50 guineas if they would give the Doctor 100 lashes. This piece of discipline would have been inflicted, had it not been for the interposition of a sturdy colonel; and the Doctor had not only the satisfaction of escaping the intended punishment, but of seeing his doctrine so far attended to, that some slaves were emancipated.

Mr Hampson, in his Memoirs of Mr Wesley, observes, that "the colonists, in the infancy of Methodism, conducted themselves with more propriety than the English. There was little or no persecution, nor any thing like a riot, except in one or two instances which have been mentioned as the consequence of the animadversions on slavery; and even these were productive of no mischief. Not a creature was materially injured; no bones were broken, nor any lives lost; which was not the case in this country. Here many thousands of innocent people were subjected to the grossest indignities, and several were eventually sacrificed to the fury of their persecutors.

"While we commend the Americans for their behaviour in opposition to the brutality of English mobs, it may be proper to inquire into the sources of this distinction. Something of this may have arisen from similarity of sentiment. The Americans, from the first beginnings of colonization, had been accustomed to the doctrines of the old puritans and nonconformists, which in many respects have a near affinity to the Methodistic tenets. The origin of Methodism in America was seldom, if ever, attended, either under the discourses of Mr Whitefield's or Mr Wesley's preachers, with those ridiculous effects with which it was accompanied in these kingdoms. Most of the preachers, who went over to the continent, having laboured for some years in Europe previous to their having crossed the water, had exhausted their wildfire; so that their discourses were more scriptural and rational than those of the primitive Methodists. Another reason may be found in the education of the Americans. As a people, they are better cultivated than the body of the English; they are chiefly composed of merchants and a respectable yeomanry: and there is but a small proportion of that class, so superabundant here, which we distinguish by the name of *mob*.

"The only exception we have heard, to their exemption from the extravagancies which in this country marked the infancy of Methodism, is a custom they have introduced in Maryland and Virginia. Frequently, at the conclusion of a sermon, the whole congregation began to pray and to praise God aloud. The uproar which this must create may easily be conceived. Some we are told, are great admirers of this species of enthusiasm, in which every man is his own minister, and one sings and another prays, with the most discordant devotion. But we will not dignify such indecency with such a name. Its proper appellation is *fanaticism*. We hope, that, for the future, religion will never appear in this country under so odious a form; and greatly is it to be lamented, that, among the friends of Christianity, any such absurdities should arise, to furnish infidels with occasions of triumph."

Our author informs us, that the occupation of the Methodist preachers in America was very laborious. In the course of the day they frequently rode 20 or 30 miles, preaching twice or thrice, and sometimes to considerable congregations. Notwithstanding this labour, however, few or none of them ever thought of returning to Britain. Several reasons may be assigned for the pleasure they took in this laborious exercise. "Their excursions (says Mr Hampson) through immense forests abounding in trees of all sorts and sizes, were often highly romantic. Innumerable rivers and falls of water; vistas opening to the view, in contrast with the uncultivated wild; deer now shooting across the road, and now scouring through the woods, while the eye was frequently relieved by the appearance of orchards and plantations, and the houses of gentlemen and farmers peeping through the trees; formed a scenery so various and picturesque, as to produce a variety of reflection, and present, we will not say to a philosophic eye, but to the mind of every reasonable creature, the most sublime and agreeable images.

"Their worship partook of the general simplicity. It was frequently conducted in the open air. The woods resounded to the voice of the preacher, or to the singing of his numerous congregations; while their horses, fastened to the trees, formed a singular addition to the solemnity. It was indeed a striking picture; and might naturally impress the mind with a retrospect of the antediluvian days, when the hills and valleys re-echoed the patriarchal devotions, and a Seth or an Enoch, in the shadow of a projecting rock, or beneath the foliage of of some venerable oak, delivered his primeval lectures, and was a "preacher of righteousness to the people."

The American hospitality is supposed by Mr Hampson to have been another reason for the assiduity of the Methodist teachers, as well as the consciousness of being well employed, and the satisfaction resulting from considerations of public utility. As many of the preachers were men of fervent piety, this reflection would have its full weight; and the instruction of the ignorant and the reformation of the profligate would be considered as the best recompense of their labours. Spreading themselves through the continent, they took in Nova Scotia, Georgia, with the principal places in both Carolinas, Virginia, Maryland, Delaware, Pennsylvania, New Jersey, and New York; numbering upwards of 43,000 members of their society, exclusive of about 80 itinerants, and a considerable number of local preachers, who took no circuits, but assisted occasionally in the neighbourhood of their respective residence.

The large and expensive buildings which the colonists have erected for public worship, almost exceed credibility; and several colleges are founded for the instruction of youth. How far the proposed plan of uniting genuine religion and extensive learning will be carried into execution, time only can discover. It must materially depend on the character of the presidents and tutors, and the provision that shall be made for their support. Men of real erudition will never be procured at low salaries; and it is in vain to attempt establishments of this sort without a liberal provision for the professors of every branch of science. Two of these places are called *Cokesbury* and *Wesley Colleges*. How they are endowed, or whether they propose to obtain authority to confer degrees, we are not informed. But perhaps they are rather schools than colleges; which indeed is a circumstance to be wished, as good grammar schools are of the utmost service to the progress of literature.

The great success which attended the Methodist preachers in America naturally determined Mr Wesley to try the West India islands. The Moravians had already attempted to establish their principles in some of these islands; and in 1786 some preachers were sent from the Methodists in England to the West Indies. In many of these they met with success. Societies were formed in Barbadoes, St Vincent's, Dominica, St Christopher's, Nevis, Antigua, St Eustatius, Tortola, and St Croix, amounting in all to near 5000 persons. At this time the whole number of Methodists in America and the West Indies amounted to about 48,302. These societies consisted both of whites and blacks: on the continent they were mostly whites, but in the islands negroes. "But it is to be observed (says Mr Hampson) that the subjection of the negroes, and the obedience in which they are trained, must inculcate a docility peculiarly favourable to the purposes of a mission." Some of the missionaries went also to St Vincent's, where they met with some success, and have established some schools, in which their children are carefully instructed in the principles of religion.

"In January 1789 (says our author), Dr Coke paid a visit to Jamaica, and gave them several sermons. As he made but a short stay, it could hardly be considered as a fair trial. Should a mission be established here, as well as in the other islands, which will probably be the case, it is hoped it will be the means of correcting one vice at least, and that is duelling; a savage relick of Gothic barbarity, by which all the islands have for many years been distinguished. Perhaps too it will give some check to the spirit of luxury and dissipation; and teach the planters, if it be found impracticable to emancipate their slaves, at least to treat them with humanity."

It has been debated among the leading men of the Methodistical profession, whether the cause might not be served by sending missionaries to the East Indies and to Africa; but these projects were dropped, as there was no invitation, nor any prospect of success if it had been adopted. A mission has been formed to the new settlement called *Kentucky*, on the confines of the Indian territories, near the Mississippi. The danger of the missionaries at the time they undertook this service was certainly very great; yet such was their zeal for the cause, that they voluntarily offered themselves: but we are not yet informed what success they have met with.

While Methodism was thus making rapid progress in America, its teachers were equally indefatigable in Britain. A most remarkable particular, however, occurs with regard to Mr Wesley himself; for though he had gone to Georgia, as has been already related, to convert the Indians to Christianity, yet on his return to England in 1738, he took it into his head that he, their teacher, was not yet converted: the reason was, that he had not the faith of assurance. This, however, was not long wanting. He arrived in England on the first day of February, and was blest with the assurance on the sixth of March following. This was immediately announced to the public; and the consequence, if we may believe him, was, that God then began to work by his ministry, which he had not done before. Being joined by one Kinchin, a fellow of Corpus, they travelled to Manchester, Holms Chapel, Newcastle in Staffordshire, and other places, where they preached, exhorted, and conversed on religious subjects, in public houses, stables, &c. sometimes meeting with success and sometimes not. During this peregrination Mr Wesley certainly displayed a great deal of superstition, which we must undoubtedly suppose to have been communicated to his hearers, and to have caused them act on many occasions in a very ridiculous manner. An instance follows:—"The next day (says he), March 11th, we dined at Birmingham, and, soon after we left it, were reproved for our negligence there (in letting those who attended us go without either exhortation or instruction) by a severe shower of hail!" About the latter end of March or beginning of April he and his companion began to pray *extempore*, leaving off entirely the forms of the church of England, to which he had formerly been so devoted. The doctrine of instantaneous conversion, which his imagination had suggested to him as a work performed on himself, was greedily received by some of his hearers; and all the converts to the new doctrine confirmed themselves, and contributed greatly to persuade others, by declarations of their *experiences*, as they called them: however,

ever, though a knowledge of the saving assurance had been given on March 6th, he does not date his conversion sooner than May 24th of the same year.

This new doctrine of an instantaneous, and in fact miraculous impulse, though greatly relished by the enthusiastical part of the society, was very much disliked by others, particularly Mr Charles Wesley his brother, who warned him of the mischief he was doing; though he himself was soon converted, and, what is very astonishing, two days before John Wesley himself. The particulars related of these miraculous conversions are truly disgraceful, and could not but bring into contempt the society which consisted of such enthusiasts. "Many (says Mr Hampson) are represented as falling suddenly to the ground, in horror and agony not to be conceived, and rising again with equal expressions of peace and consolation."—Their conversions were usually attended with these violent symptoms; and, for several years, few meetings occurred where Mr Wesley presided, without one or more instances of the same kind. It was not possible that such transactions should pass without notice. The confusion that too often prevailed, the emotions of the persons affected, and the exultations of the rest, which were severally animadverted upon, gave great and general offence. Many insisted, that it must either be occasioned by the heat of the rooms, and the agitation of the animal spirits under discourses of the most alarming nature; or that it was mere artifice and hypocrisy.

In the mean time, two of the sons of a Mrs Hutton in London, happening to become converts to the new doctrine, this lady was so much offended, that she wrote to Mr Samuel Wesley, informing him, that she was of opinion his brother John had lost his senses; and requesting, that the next time he came to his house, he, Mr Samuel, would either confine or convert him. All that could be done, however, to prevent the progress of the new doctrine was insufficient; and the first Methodist society was formed in London on the first of May 1738, when about 50 agreed to meet together once a-week, for free conversation, begun and ended with singing and prayer.

All this time, however, it seems that the conversion of Mr Wesley was far from being so complete as that of many of his hearers. He had preached and converted others, while he himself was absolutely unconverted. The knowledge of the true saving faith was only revealed to him on the 6th of March, and he did not experience its power till the 24th of May; and even after this, his doubts and fears were still so great, that on the 13th of June he undertook a voyage to Germany, where, in the company of Count Zinzendorff, his faith seems to have been thoroughly confirmed.

On Mr Wesley's return, September 16th, 1738, he applied himself with the greatest assiduity and success to the propagation of his doctrine. Multitudes of converts were made in various parts of the kingdom; and the reproaches poured upon him by his opponents, seemed to have rendered his zeal more fervent if possible than before. It is remarkable, however, that some of his old friends were now so much offended with his conduct or his principles, that they absolutely refused to keep company with him. His original plan seems to have been, to make an union of clergymen, and disseminate his principles by their means. But in this he succeeded so ill, that in a letter written in 1742, he wished for a clerical assistant, were he only in deacons orders: but adds, "I know of none such, who is willing to cast in his lot with us; and I scarce expect I shall, because I know how fast they are rivetted in the service of the devil and the world before they leave the university."—Finding at last that nothing could be done with them, he was obliged to have recourse to lay preachers; and easily selected those who appeared to have the greatest talents for prayer and exhortation in the private meetings appointed for that purpose. Thus he at once raised himself to be the head of a sect; as the lay preachers willingly yielded obedience to him who had the advantages of superior learning and abilities, and was besides in orders as a clergyman; and this obedience he did not fail on every occasion to exact.

If his doctrine had formerly given offence to the established clergy, the appointment of lay preachers was reckoned much worse; and their being appointed without any form of ordination whatever, which almost all of them were, subjected them to contempt and reproach, which their want of learning, and very often of natural abilities, did not contribute to remove. Thus finding the churches shut against him and his followers, he was obliged to preach in the fields, and made his first essay in this way on the second of April 1739, in the neighbourhood of Bristol; Mr Whitefield having set him an example the day before.

The success of those ignorant and itinerant preachers, with their absurd and uncharitable discourses and behaviour, so provoked their adversaries, that a persecution was soon commenced against them. Mr Wesley himself was calumniated in the harshest manner, being sometimes said to be a Jesuit, sometimes an illiterate enthusiast, as the people took it into their heads. Many pretended to answer him in writing, without being able to do so: the consequence was, that their deficiency of argument was supplied by invective, and the most scandalous performances made their appearance. Some of the English clergy so far forgot themselves as to instigate the mob against them, and the most cruel outrages were committed upon them in various places. For some time the persecuted party adhered to the doctrines of passive obedience and non-resistance, which their inhuman adversaries did not fail to take the advantage of.—The less they were opposed, the more insolent they became. The Methodists were frequently in danger of their lives. Men, women with child, and even children, were knocked down and abused with the same undistinguishing fury. Houses were stripped of their furniture, vast quantities of furniture carried off, featherbeds cut in pieces and strewed over the streets, several reputable people were forced into the army, &c. To the disgrace of magistracy also it was found, that when application was made to the justices of the peace, redress was commonly denied; nor was a stop put to these shameful proceedings without a royal mandate for the purpose.

From the year 1738 to 1747 Mr Wesley and his itinerants were employed in various parts of England. In

Methodists.

In 1747 he went over to Dublin, where a society had been formed by one Mr Williams a clergyman.—Here they proved so successful, notwithstanding the number of Papists, and the violence of their other opponents, that in 1750 they had erected meeting-houses in every part of the kingdom, and had formed 29 circuits, which employed 67 itinerants, besides a considerable number of local preachers. An invitation was given to Mr Wesley, in 1751, to visit Scotland, by an officer in quarters at Musselburgh. He accordingly took a journey thither the same year; but left the place, after preaching in it once or twice. In 1753 he returned to Scotland, and visited Glasgow. Societies were at length formed in that city, as well as at Edinburgh, Dundee, Aberdeen, Inverness, and a few other places: but his success was by no means equal to what it had been in other parts; for in 1790 the number of circuits in Scotland was no more than eight, which were supplied by 20 itinerants.

Mr Whitefield, the other great labourer in the vineyard, was equally indefatigable, and probably more successful than Mr Wesley. Before entering into orders, he had formed a society of religious persons at Gloucester: here he preached his first sermon on the Necessity and Benefit of Religious Society; here he became extremely popular, as well as at Bristol and London, while preparing to set sail for Georgia for the first time; and in all places to which he came, large collections were made for the poor. He maintained the same doctrine with Mr Wesley as to the new birth; which likewise gave offence to the clergy when delivered by him, as it had done with Mr Wesley. In the various intervals of his voyages to America, he employed himself with the very same assiduity in Britain and in Ireland, which we have already taken notice of in the western continent. His success was everywhere prodigious. In 1741 he was invited to Scotland, and preached his first sermon there at Dunfermline. From thence he went to Edinburgh, and preached in several of the established churches, but differed with Messrs Ralph and Ebenezer Erskine; so that he, as well as Mr Wesley, proved unsuccessful in forming a coalition with any other religious party. In the private way, however, his success was very considerable, at Edinburgh, Glasgow, Aberdeen, Dundee, and other places. In 1742 he paid a second visit to Scotland, and a third one in 1748. In 1751 he visited Ireland for the first time; and preached to great multitudes, without being molested, even in places where others had been mobbed. From thence he returned to Scotland the same year, and speaks in very favourable terms of the attention the people there paid to their Bibles. In 1752 and 1753 he again visited the same kingdom, and the last time distinguished himself by preaching against the playhouse in Glasgow. In 1756 he returned; and by his animated discourses at Edinburgh against Popery and arbitrary power, was owned to have contributed very much to the increase of courage and loyalty in this country. Next year he again visited the Scottish capital during the time that the General Assembly sat, and his sermons were attended by several of the members. At Glasgow he made a large collection for the poor of that city, and from thence took a voyage to Ireland. He was received with the usual affection by the lower classes of Protestants; but the Popish rabble, exasperated at his success, almost murdered him with stones. After passing through a great part of Ireland, visiting England and Wales, he paid another visit to Scotland, where four clergymen now lent him their pulpits. His last visit was in the summer of 1758, when his congregations were as large as ever; and it is to his endeavours principally that we are to ascribe the great number of Methodist societies now existing in Scotland.

With regard to the religious principles of the Methodists, we cannot enter into any particular detail; neither indeed are there any doctrines peculiar to all included under that name, except the single one of universal redemption. In March 1741, Mr Whitefield being returned to England, entirely separated from Mr Wesley and his friends, "because he did not hold the decrees."—Here was the first breach, which warm men persuaded Mr Whitefield to make, merely for a difference of opinion. Those indeed who believed universal redemption, had no desire at all to separate: but those who held particular redemption, would not hear of any accommodation, being determined to have no fellowship with men that "were in such dangerous errors." So there were now two sorts of Methodists so called; those for particular, and those for general redemption.

History of Methodism, &c.

Not many years passed, before William Cudworth and James Relly separated from Mr Whitefield.—These were properly Antinomians, absolute avowed enemies to the law of God, which they never preached or professed to preach, but termed all *legalists* who did. With them, preaching the law was an abomination. They had nothing to do with the law. They would preach Christ, as they called it; but without one word either of holiness or good works. Yet these were still denominated *Methodists*, although differing from Mr Whitefield both in judgment and practice, abundantly more than Mr Whitefield did from Mr Wesley.

In the mean time, Mr Venn and Mr Romaine began to be spoken of: and not long after Mr Madan and Mr Berridge, with a few other clergymen, who, although they had no connexion with each other, yet preaching salvation by faith, and endeavouring to live accordingly, to be Bible Christians, were soon included in the general name of *Methodists*. And so indeed were all others who preached salvation by faith, and appeared more serious than their neighbours. Some of these were quite regular in their manner of preaching: some were quite irregular, (though not by choice; but necessity was laid upon them, they must preach irregularly, or not at all): and others were between both; regular in most, though not in all particulars.

In 1762, George Bell and a few other persons began to speak great words. In the latter end of the year they foretold that the world would be at an end on the 28th of February. Mr Wesley, with whom they were then connected, withstood them both in public and private. This they would not endure: so, in January and February 1763, they separated from him, under the care of Mr Maxfield, one of Mr Wesley's preachers. But still Mr Maxfield and his adherents,

rents, even the wildest enthusiasts among them, go under the general name of *Methodists*, and so bring a scandal upon those with whom they have no connexion.

At present, those who remain with Mr Wesley are mostly Church of England men. They love her articles, her homilies, her liturgy, her discipline, and unwillingly vary from it in any instance. Mean time, all who preach among them declare, *we are all by nature children of wrath, but by grace we are saved through faith*: saved from both the guilt and from the power of sin. They endeavour to live according to what they preach, to be plain Bible Christians; and they meet together at convenient times, to encourage one another therein. They tenderly love many that are Calvinists, though they do not love their opinions. Yea, they love the Antinomians themselves; but it is with a love of compassion only, for they hate their doctrines with a perfect hatred; they abhor them as they do hell fire: being convinced nothing can so effectually destroy all faith, all holiness, and all good works.

We shall conclude this article with the words of Mr Hampson, which must certainly be accounted just, whatever objections may be made to some parts of the principles or behaviour of the Methodists. "If they possess not much knowledge, which, however, we do not know to be the case, it is at least certain, they are not deficient in zeal: and without any passionate desire to imitate their example, we may at least commend their endeavours for the general good. Every good man will contemplate with pleasure the operation of the spirit of reformation, whether foreign or domestic; and will rejoice in every attempt to propagate Christianity in the barbarous parts of the world. An attempt which, if in any tolerable degree successful, will do infinitely more for their civilization and happiness, than all the united energies of those boasted benefactors of mankind, the philosophic infidels."

The minutes of the conference of the Methodists held at Leeds in August, 1806, represent the numbers of that society to be as follows:

In Great Britain,	110,803
In Ireland,	23,773
Gibraltar,	40
Nova Scotia, New Brunswick, and Newfoundland,	1418
West Indies, whites 1775, coloured people 13,165,	14,940
United States, whites 95,628, coloured people 24,316,	119,945
Total,	270,919

METHODISTS (*Methodici*), in the history of medicine, a sect of ancient physicians, who reduced the whole art of healing to a few common principles or appearances. The Methodists were the followers of Thessalus; whence they were also called *Thessalici*. They were strenuously opposed by Galen in several of his writings; who scrupled not to assert, that the methodical heresy ruined every thing that was good in the art. According to Quincy, the *Methodists* (*Methodici*) are those physicians who adhere to the doctrine of Galen, and the schools; and who cure with bleeding, purges, &c. duly applied according to the symptoms, circumstances, &c. in opposition to empirics and chemists, who use violent medicines, and pretended secrets or nostrums.

METHUSELAH, the son of Enoch and father of Lamech, was born in the year of the world 687, begat Lamech in 874, and died in 1656, being the very year of the deluge, at the age of 969, which is the greatest age that has been attained to by any mortal man upon earth (Gen. v. 21, 22, &c.). According to the text of the Septuagint, Methuselah must have lived 14 years after the deluge; and according to other copies, he died six years before it: but it is generally agreed on, that these copies, as well as the Septuagint, are corrupted in this place.

METHYMNA, in *Ancient Geography*, a town the island of Lesbos. It was the second city of the island in greatness, population, and opulence. Its territory was fruitful, and the wines it produced excellent. It was the native place of Theophrastus, and of Arion the musician. When the whole island of Lesbos revolted from the power of the Athenians, Methymna alone remained firm to its ancient allies.

METOECI, a name given by the Athenians to such as had their fixed habitations in Attica, though foreigners by birth. The *metœci* were admitted by the council of Areopagus, and entered in the public register. They differed both from the πολιται and ξενοι; because the *politæ* or "citizens" were freemen of Athens, and the *xeni* or "strangers" had lodgings only for a short time; whereas the *metœci* though not freemen of Athens, constantly resided upon the spot whither they had removed.

METONYMY, in *Rhetoric*, is a trope in which one name is put for another, on account of the near relation there is between them. See ORATORY, N° 51.

METOPE, in *Architecture*, is the interval or square space between the triglyphs of the Doric frieze, which among the ancients used to be painted or adorned with carved work, representing the heads of oxen or utensils used in sacrifices.

METOPOSCOPY, the pretended art of knowing a person's dispositions and manners by viewing the traces and lines in the face. Ciro Spontoni, who has written expressly on metoposcopy, says, that seven lines are examined in the forehead, and that each line is considered as having its particular planet: the first is the line of Saturn, the second of Jupiter, the third of Mars, &c. Metoposcopy is only a branch of physiognomy, which founds its conjectures on all the parts of the body.

METRE, μετρον, in *Poetry*, a system of feet of a just length.

The different metres in poetry, are the different manners of ordering and combining the quantities, or the long and short syllables; thus hexameter, pentameter, iambic, sapphic verses, consist of different metres or measures. See HEXAMETER.

In English verses, the metres are extremely various and arbitrary, every poet being at liberty to introduce any new form that he pleases. The most usual are the heroic, generally consisting of five long and five short syllables, and verses of four feet, and of three feet, and a cæsura or single syllable.

The ancients, by variously combining and transposing their quantities, made a vast variety of different measures,

measures, by forming spondees, &c. of different feet. See POETRY.

METRETES, a Grecian measure, containing something more than nine English gallons. See MEASURE.

METRICAL VERSES, are those consisting of a determinate number of long and short syllables; as those of the Greek and Latin poets.—Capellus observes, that the genius of the Hebrew language is incompatible with metrical poetry.

METROCOMIA (from μήτηρ, *mother*, and κωμη, *town* or *village*), a term in the ancient church-history, signifying "a borough or village that had other villages under its jurisdiction."—What a metropolis was among cities, a *metrocomia* was among country towns. The ancient *metrocomiæ* had each its chorepiscopus or rural dean, and here was his see or residence. See METROPOLIS and CHORIEPISCOPUS.

METRONOMII, the name given by the Athenians to five officers in the city and ten in the *Piræus*, whose duty it was to inspect all sorts of measures except those of corn. The *Piræus* was the greatest mart in Attica.

METROPOLIS (from μητηρ, *mother*, and πολις, *city*), the capital of a country or province; or the principal city, and as it were mother of all the rest.

The term METROPOLIS is also applied to archiepiscopal churches, and sometimes to the principal or mother-church of a city. The Roman empire having been divided into 13 dioceses and 120 provinces, each diocese and each province had its metropolis or capital city, where the proconsul had his residence. To this civil division the ecclesiastical was afterwards adapted, and the bishop of the capital city had the direction of affairs, and the pre-eminence over all the bishops of the province. His residence in the metropolis gave him the title of *metropolitan*. This erection of metropolitans is referred to the end of the third century, and was confirmed by the council of Nice. A metropolitan has the privilege of ordaining his suffragans; and appeals from sentences passed by the suffragans are preferred to the metropolitan.

METROPOLIS, in *Ancient Geography*, a town of Acarnania, a little to the south of Stratos.—Another, of Lydia; situated between Colophon and Priene, near the Caÿster.—A third, of Phrygia; sacred to the mother of the gods, who was here worshipped.—A fourth Metropolis of Estiotis, a district in Thessaly, to the east of Gomphi, and the last town of that district. *Metropolitæ*, the people.

METULUM, in *Ancient Geography*, a considerable city of Liburnia, at the siege of which Octavius Cæsar was wounded. Said to be the metropolis, and situated on two eminences, intersected by a valley (Appian). Now generally thought to be *Metling* in Carniola. E. Long. 16. N. Lat. 46. 5.

METZ, an ancient, large, and strong town of France, and capital of the territory of Messin, with a citadel and a bishop's see, whose bishop used to hold the title of a prince of the empire. The cathedral church is one of the finest in Europe, and the square called *Coslin* and the house of the governor are worth seeing. The Jews live in a part of the town by themselves, where they have a synagogue. The sweetmeats they make here are in high esteem. It is seated at the confluence of the rivers Moselle and Seille. E. Long. 6. 16. N. Lat. 49. 7.

MEVANIA, in *Ancient Geography*, a town of the Cisapennine Umbria; seated at the confluence of the Tina and Clitumnus, on the Via Flaminia, famous for its herds of white cattle brought up there for sacrifice; the white colour said to be owing to the waters of the Clitumnus (Virgil). Mevania was the country of Propertius. *Mevenates* the people. Now said to be *Bevagna*, in the territory of the Pope.

MEURSIUS, JOHN, a learned and laborious writer, was born at Losdun, near the Hague, in 1579. He early discovered a fondness for polite literature and the sciences; and went to study law at Orleans with the son of Barneveldt, whom he accompanied in his travels. In 1610 he was made professor of history at Leyden, and afterwards Greek professor. In the following year, the magistrates of the United Provinces proved how high their opinion was of his abilities, by fixing on him to write the history of his country. Meursius married in the year 1612. His wife, Anna Catherina Bilberbeccia, descended from a very ancient and noble family in Angermond a city of Pomerania, possessed many amiable qualities, and rendered his domestic life remarkably happy, while he discharged the duties of his professorship with an assiduity equal to his abilities. At the same time the republic of letters did not lose the advantages to be derived from his labours; for during the fourteen years of his residence at Leyden, the works which he published were more numerous than those which had been presented to the world by the whole body of professors from the original foundation of the university in 1575.

Meursius's writings had now spread his reputation in every part of Europe; nor was the fame of his diligence and talents as a professor less known. In so high a rank, indeed, did he stand among his literary contemporaries, that Christian IV. king of Denmark conferred on him the place of historiographer royal, and invited him to undertake the professorship of history and politics in the academy of Sora, which was founded by King Frederick II. although the revival of its honours and dignities may be dated from this period, when it seemed to be again founded under the auspices of Christian IV. Meursius and his family left Leyden in the year 1635. On his arrival at Sora, he was received with the most friendly tokens of regard by his majesty and the Danish nobility, and more particularly by Chancellor Rosenkrantz, on whom he has bestowed very ample praises in one of his letters. Here he resided, equally beloved and admired, for above twelve years. His pupils were not very numerous, but his exertions never relaxed. Those hours likewise which were not devoted to the duties of his professorship, he employed in revising the works of the ancients and in philological disquisitions.

His health did not suffer by the intenseness of application, till in the year 1638 he had a violent attack of the stone, from which disorder he had suffered severely. In a letter to Vossius he thus describes his melancholy condition: "The state of my health during the whole of the last winter has been truly deplorable. My sufferings from the stone have been really dreadful. I have voided so many, that the repeated discharges brought on a wound which emitted

Meursius. ted blood for above four months. I was next attacked by a tertian fever, which increased constantly, and produced an universal lassitude of body, a dejection of spirits, and a total loss of appetite. But, thank heaven, I have now in some measure recovered my strength, and gotten the better of these complaints." He recovered from this attack; but in the following year the disorder returned with redoubled violence, and brought on a consumption, which terminated his existence on the 20th day of September 1639. He left behind him a son who was named after him, and one daughter.

So mild were the dispositions of Meursius, that in all his writings he constantly avoided literary disputes. He was sometimes unavoidably drawn into them; but constantly endeavoured to promote a reconciliation rather than widen any breach, by his replies to the attacks of his adversaries. In his friendships he was firm and affectionate. Of his domestic life, whatever is known has been gathered from his letters. The same easy tranquillity seems to have attended him in every situation. In his family he was particularly fortunate. In his son, to whom he gave his own name, he seemed to behold his own youth renewed. The same application, the same eagerness in the pursuit of knowledge, marked the conduct of this promising young man; who did not long survive his father, but died soon after he had recommended himself to the notice of the learned world by his publications. They were only three in number; but displayed so much solid learning that they have been assigned to the father, John Meursius, by l'Abbé Beughem and others. This mistake was occasioned as much by the similitude of their names, as by the nature of their works, and their manner of treating philological subjects.

His works may be divided into four classes, of which each might form a separate volume if they were ever to be republished. Meursius himself indeed, in one of his letters to Vossius, proposes such a division. From that epistle, and from another which the younger Meursius sent to G. I. Vossius, who strongly advised him to republish the whole of his father's writings, and from the collections of his posthumous works which have appeared from Struvius, Groschupsius, Moller, and some others, a catalogue of his works might be formed. Some assistance will also be derived from the indexes published in their respective works, by Hankins, Desselius, Wettenius, and Bartholinus. The plan which Meursius recommends for publishing his works, is to insert in the first volume all that he has written relative to Athens; in the second, his historical pieces; in the third his miscellaneous dissertations; and in the fourth, the various authors which he published, with his notes and corrections,.

Meursius || Mexico.

A scandalous and indecent work, which is entitled *Meursii elegantiæ Latini sermonis* ,and has *Aloisiæ Sigeæ Satyræ Sotadicæ* annexed to it, is very falsely attributed to Meursius; nor indeed are the *Satires* with more reason assigned to Aloisia Sigea, who was a Spanish lady eminent for her piety and virtue. The real author of these infamous productions was Westrenius, an advocate at Copenhagen, who probably assumed the name of Meursius, in order to shield himself from the disgrace which would naturally have attended the writer of such a performance.

MEW, SEA-MEW, or *Sea-mall.* } See LARUS, ORNITHOLOGY *Index.*
Winter MEW, or *Coddy-moddy.* }

MEWING, the falling off or change of hair, feathers, skin, horns, or other parts of animals, which happens in some annually, in others only at certain stages of their lives; but the generality of beasts mew in the spring. An old hart casts his horns sooner than a young one, which is commonly in the months of February and March: after which they begin to button in March or April: and as the sun grows strong, and the season of the year puts forth the fruits of the earth, so their heads grow, and are summed full by the middle of June. It is to be observed, that if a hart be gelt before he has a head, he will never have any; and if he be gelt after he has a head, he will never cast his horns; again, if he be gelt when he has a velvet head, it will always be so, without fraying or burnishing.

MEXICO,

History.

A PROVINCE of the Spanish empire in America, once a celebrated kingdom, the most powerful and civilized in the new world; lying between the 14th and 21st degrees of north latitude, and between 91 and 103 degrees west longitude; being near 2000 miles in length, and in some places 600 miles in breadth.

1 Toltecans the first inhabitants.

The Toltecans are the most ancient Mexican nation of which we know any thing. They were expelled, as we are told, from their own country (supposed by Clavigero to have been *Tollan*, to the northward of Mexico) in the year 472; and for some time led a wandering life. In whatever place they determined to reside for any considerable time, they erected houses and cultivated the ground. Thus their migrations were extremely slow, and it was not till 104 years after they set out that they reached a place about 50 miles to the eastward of the city of Mexico, where they settled for 20 years, giving to their new place of residence the name of *Tollantzinco*. From thence they proceeded about 40 miles farther to the west, where they built a city called, from the name of their country, *Tollan*, or *Tula*.

2 Their history.

After the final settlement of the Toltecans, the government was changed into a monarchy. Their first king began his reign in 667, and their monarchy lasted 384 years, during which time they reckon just eight princes. We are not, however, to imagine that each of their kings lived long enough to make up this space. It was a custom among them that the name of the king should be continued for 52 years, and no longer, from the time he ascended the throne. If he died within that period, the government was carried on in his name by a regency; if he survived, he was obliged to resign his authority. During the four centuries that the Toltecan monarchy continued, they had increased very considerably in number, and had built many cities; but when in the height of prosperity, almost the whole

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whole nation was destroyed by a famine occasioned by drought; and a pestilence, probably the consequence of the former. "According to Torquemada (says our author), at a certain festival-ball made by the *Toltecans*, the *sad-looking* devil appeared to them of a gigantic size, with immense arms, and in the midst of the entertainment he embraced and suffocated them; that then he appeared in the form of a child with a putrid head, and brought the plague; and, finally, at the persuasion of the same devil, they abandoned the country of Tula."

3 Succeeded by the Chichemecas.

They were succeeded by the Chichemecas, a much more barbarous people, who came from an unknown country called *Amaquemecan*, where they had for a long time resided; but of which no traces of remembrance can be found among any of the American nations known to Europeans; so that Clavigero supposes it must have been very far to the northward.

The motive which the Chichemecas had for leaving their own country is not known. They were eighteen months on their journey, and took possession of the desolate country of the Toltecans about an hundred years after the former had left it. They were much more uncivilized than the Toltecans; but, however, had a regular form of monarchical government, and in other respects were less disgusting in their manners than some of the neighbouring nations. The last king who reigned in Amaquemecan before the departure of the Chichemecas, had left his dominions between his two sons Auchcauhtli and Xolotl, and the latter conducted the new colony. Having proceeded from the ruins of Tula towards Chempoalla and Tepepolio, Xolotl sent his son to survey the county. The prince crossed the borders of the lakes and the mountains which surround the vale of Mexico; then ascending to the top of a very high one, he viewed the whole country, and took possession of it in the name of his father, by shooting four arrows to the four winds.

4 Xolotl their first king.

Xolotl being informed by his son of the nature of the country, chose for the capital of his kingdom Tenayuca, about six miles to the northward of the city of Mexico, and distributed his people in the neighbouring territory; but as most of them went to the northward, that part obtained the name of the country of the Chichemecas, in distinction from the rest. Here a review of the people was taken, and their number, according to Torquemada, was more than a million.

Xolotl finding himself peacefully settled in his new dominion, sent one of his officers to explore the sources of some of the rivers of the country. While performing this task he came to the habitations of some Toltecans, who it seems had still kept together, and were likely once more to become a nation. As these people were not inclined to war, and greatly esteemed for their knowledge and skill in the arts, the Chichemecas entered into a strict allianee with them, and Prince Nopaltzin, who had first surveyed the country, married a Toltecan princess. The consequence of this alliance was the introduction of the arts and knowledge of the Toltecans among the Chichemecas. Till now the latter had subsisted entirely by hunting, and such fruits and roots as the earth spontaneously produced. They were clad in the skins of wild beasts, and, like these beasts, they are said to have sucked the blood of the animals they caught; but after their connection with the Toltecans they began to sow corn, to learn the art of digging and working metals, to cut stones, manufacture cotton, and, in every respect, to make great improvements.

5 His people civilized by the Toltecans.

6 New inhabitants arrive and obtain settlements.

When Xolotl had reigned about eight years in his new territories, an embassy of six persons arrived from a distant country not far from *Amaquemecan*, expressing a desire of coming with their people to reside in the country of the Chichemecas. The king gave them a gracious reception, and assigned them a district; and, in a few years after, three other princes, with a great army of Acolhuans, who were likewise neighbours of Amaquemecan, made their appearance. The king was at that time at Tezcuco, to which place he had removed his court: and here he was accosted by the princes, who, in a submissive and flattering manner, requested him to allow them a place in his happy country, where the people enjoyed such an excellent government. Xolotl not only gave them a favourable reception, but offered them his two daughters in marriage, expressing his concern that he had no more, that none might have been excluded from the royal alliance. On the third prince, however, he bestowed a noble virgin of Chalco, in whom the Toltecan and Chichemecan blood were united. The nuptials were celebrated with extraordinary pomp; and the two nations, after the example of the sovereigns, continued to intermarry. As the Acolhuans were the more civilized nation of the two, the name of Chichemecas began to be appropriated to the more rude and barbarous part, who preferred hunting to agriculture, or chose a life of savage liberty in the mountains to the restraints of social laws. These barbarians associated with the Otomies, another savage nation who lived to the northward, occupying a tract of more than three hundred miles in extent; and by their descendants the Spaniards were harassed for many years after the conquest of Mexico.

7 Division of the dominions of Xolotl.

As soon as the nuptial rejoicings were over, Xolotl divided his territories into three parts, assigning one to each of the princes. Acolhuatzin, who had married his eldest daughter, had Azcopazalco, 18 miles to the westward of Tezcuco; Chiconquauhtli, who married the other, had a territory named Xaltocan; and Tzontecomatl, who married the lady of inferior rank, had one named Coatlichan. The country continued for some time to flourish, population increased greatly, and with it the civilization of the people; but as these advanced, the vices of luxury and ambition increased in proportion. Xolotl found himself obliged to treat his subjects with more severity than formerly, and even to put some of them to death.—This produced a conspiracy against him, which, however, he had the good fortune to escape; but while he meditated a severe revenge on the conspirators, he was seized with the distemper of which he died, in the fortieth year of his reign, and in a very advanced age.

8 Nopaltzin the second king.

Xolotl was succeeded by his son Nopaltzin, who at the time of his accession is supposed to have been about sixty years of age. In his time, the tranquillity of the kingdom, which had begun to suffer disturbance under his father, underwent much more violent shocks, and civil wars took place. Acolhuatzin, the only one of the three princes who remained alive, thinking the territory he possessed too narrow, made war upon the lord of a neighbouring province named Tapotzotlan,

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Tapotzotlan, and deprived him of his territory. Huetzin, son to the late Prince Tzontecomatl, lord of Coatlichan, fell in love with the grand-daughter of the queen, a celebrated beauty, but was rivalled by a neighbouring lord, who determined to support his pretensions by force of arms. Huetzin, however, got the better, defeated and killed his adversary, and then possessed himself of the lady and his estate. This was followed by a rebellion of the whole province of Tollantzinco, so that the king himself was obliged to take the field. As the rebels were very numerous, the royal army was at first defeated; but having at last received a strong reinforcement, the rebels were overcome, and their ringleaders severely punished. The king did not long survive the restoration of tranquillity to his dominions. He died in the thirty-second year of his reign, and ninety-second of his age, leaving the throne to his eldest son Tlotzin, who was an excellent prince, and reigned thirty-six years.

9 Quinatzin a luxurious prince.

Quinatzin, the son and successor of Tlotzin, proved a vain and luxurious prince. His accession to the throne was celebrated with much greater pomp than any of his predecessors. Xolotl had removed his court from Tenayuca to Tezcuco; but being disgusted with this last place, on account of the conspiracy formed against him there, he had returned to Tenayuca.—There the court continued to the reign of Quinatzin, who removed it back to Tezcuco.

10 Disturbances in various parts.

The reign of Quinatzin, though tranquil at first, was soon disturbed by dangerous revolts and rebellions. These first broke out in two states, named Maztillen and Totopec, situated among the northern mountains. The king, having collected a great army, marched without delay against the rebels, and challenged their leaders to come down and fight him in the plain.—This challenge being accepted, a furious engagement ensued, in which, though great numbers fell on both sides, no decisive advantage was gained by either party. Frequent engagements took place for the space of forty days, until at last the rebels perceiving that their own numbers were daily diminishing, without any possibility of being recruited like the royal army, made a final surrender to the king, who punished the ringleaders with great severity. Tranquillity, however, was not yet restored: the rebellion spread to such a degree, that the king was obliged not only to take the field in person, but to employ six other armies, under the command of faithful and experienced generals, to reduce the rebels. These proved so successful in their enterprises, that in a short time the rebellious cities were reduced to obedience, and the kingdom enjoyed the blessings of peace during the long reign of Quinatzin, who is said to have sat on the throne for no less than sixty years. He was succeeded by his son Techotlatla; but as the affairs of the Acolhuans now began to be connected with those of the Mexicans, it will be proper to give some account of that people.

11 Migrations of the Mexicans.

The Mexicans, called also the Aztecas, dwelt till the year 1160 in a country called *Aztlan*, situated to the north of the gulf of California, as appears by the route they pursued in their journey; but how far to the northward we are not certainly informed. Betancourt makes it no less than 2700 miles, and Boturini says it was a province of Asia. The cause of their migration is said to have been as follows:

Among the Aztecas was a person of great authority, named *Huiztilin*, to whose opinion every one paid the utmost deference. He had conceived a design to persuade his countrymen to change their residence; and to effect this he fell upon the following stratagem. Having heard, while meditating on his scheme, a little bird singing on the branches of a tree, the notes of which resembled the word *Tihui*, which in the Azteca language signified "let us go," he took that opportunity to work upon the superstition of the people. With this view, he took along with him a respectable person, and made him attend to the note of the bird. "What can it mean (says he), but that we must leave this country, and find ourselves another? Without doubt it is the warning of some secret divinity who watches over our welfare: let us obey, therefore, his voice, and not draw his anger upon us by a refusal." Tecpaltzin, for that was the name of his friend, readily agreed to the interpretation; and both of them being persons of great influence, their united persuasions soon gained over to their project the bulk of the nation, and they accordingly set out.

12 Separation of the tribes.

The Aztecas, when they left their original habitations, were divided into six tribes; but at Culiacan the Mexicans were left with their god * by five of them, viz. the Xochimilcas, Tepanecas, Chalcese, Tlahuicas, and Tlascalans. The cause of this separation is not known, but it was probably occasioned by some disagreement among themselves; for the remaining tribe was divided into two violent factions, which persecuted one another: neither did they afterwards construct any more edifices. However, they always travelled together, in order to enjoy the company of their imaginary god. At every place where they stopped an altar was erected to him; and at their departure they left behind them all their sick, and probably also some others to take care of them, or such as were not willing to endure the fatigue of farther journeys. They stopped in Tula nine years, and eleven more in the neighbouring parts. At last, in 1216, they arrived at Zumpanco, a considerable city in the vale of Mexico, where they were received in a very hospitable manner by the lord of that district. He not only assigned them proper habitations, but became very much attached to them; and even demanded from among them a wife for his son Ilhuicatl. This request was complied with; and from this marriage all the Mexican kings descended.

* *A wooden image.*

13 The Mexicans persecuted.

The Mexicans continued to migrate from one place to another along the lake of Tezcuco. Xolotl, who was then on the throne of the Acolhuans or Chichemecas, allowed them to settle in whatever places of his dominions they thought proper; but some of them finding themselves harassed by a neighbouring lord, were obliged in 1245, to retire to Chapoltepec, a mountain on the western borders of the lake, scarcely two miles distant from the site of Mexico. This took place in the reign of Nopaltzin, when disturbances began to take place in the Acolhuan dominions. The Mexicans, however, did not find themselves any more secure in their new place of residence than formerly: they were persecuted by the neighbouring lords, and obliged to take refuge in a number of small islands, named *Acocolco*, at the southern extremity of the lake of Mexico. Here for 52 years they lived in the most

miserable

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miserable manner, subsisting on fish, insects, roots, &c. and clothing themselves with the leaves of the amoxtli, which abounds in that lake.

14 and enslaved.

In this miserable plight the Mexicans continued till the year 1314, when they were reduced to a state of the most absolute slavery. This was done by the king of a petty state named Colhuacan, who, it is said, being unwilling to allow the Mexicans to maintain themselves in his territories without paying tribute, made war upon them, subdued and enslaved them. Others affirm that, pretending compassion for their miserable situation, he offered them a more commodious place of residence. The Mexicans readily accepted the offer; but had scarcely set out to take possession of their new place of residence when they were attacked by the Colhuans, made prisoners, and carried off for slaves.

15 Regain their liberty by cruelty.

After some years a war broke out betwixt the Colhuans and Xochimilcas, in which the latter gained such advantages, that they were obliged to employ their slaves to assist them. They accordingly ordered them to prepare for war, but without furnishing them with arms necessary for a military enterprise; so that the Mexicans were obliged to content themselves with long staves, having their points hardened in the fire; they also made knives of the stone iztli, and shields of reeds woven together. They agreed not to waste their time in making prisoners, but to content themselves with cutting off one ear of their enemies, and then leaving them without farther injury. They adhered punctually to this resolution; and rushing furiously upon the Xochimilcas, cut off an ear from as many as they could, killing those who struggled to such a degree that they could not effect their purpose. In short, so well did the Mexicans acquit themselves in this engagement, that the Xochimilcas fled, and took refuge among the mountains. After the battle, the Colhuan soldiers presented themselves before their general with the prisoners they had taken, by the number of which alone they judged of their valour. The Mexicans had taken only four, and these they kept concealed for the abominable purpose of sacrificing them. The Colhuans, therefore, seeing no trophies of their valour, began to reproach them with cowardice; but the Mexicans, producing their baskets of ears, desired them to judge from these how many prisoners they might have taken, had they not been unwilling to retard their victory by taking up time in binding them.

Notwithstanding the valour displayed by the Mexicans in this engagement, it doth not appear that their haughty masters were in the least inclined to afford them easier terms than before. Having erected an altar to their god, they demanded of their lord something precious to offer in sacrifice to him; but he in disdain sent them a dirty cloth, enclosing the filthy carcass of a vile bird. This was carried by Colhuan priests; and without any ceremony laid upon the altar. The Mexicans, with apparent unconcern, removed this filthy offering,

16 The first human sacrifice in Mexico.

and put in its place a knife made of iztli, and an odoriferous herb. On the day of consecration, the Colhuan prince attended with his nobility; not with a view to do honour to the festival, but to make a mockery of the Mexicans. Their derision, however, was soon changed into horror, when the Mexicans, after a solemn dance, brought forth the four Xochimilcan prisoners they had taken; and, after having made them dance a little, cut open their breasts with the knife which lay on the altar, and plucking out their hearts, offered them, while yet palpitating with life, to their diabolical idol. This had such an effect upon the spectators, that both king and subjects desired the Mexicans immediately to quit their territories and go where they pleased. This order was instantly obeyed: the whole nation took their route towards the north, until they came to a place named *Acatzitzintlan*, situated betwixt two lakes, and afterwards named *Mexicaltzinco;* but for some reason or other, being discontented with this situation, as indeed they seem very often to have been, they proceeded to *Iztacalco*, still nearer to the site of Mexico. Here they formed the image of a little mountain of paper, and danced round it a whole night, singing their victory over the Xochimilcas, and reuniting thanks to their god for having freed them from the yoke of the Colhuans. Clavigero is of opinion, that by this mountain they represented Colhuacan, as in their pictures it was always represented by a hunch-backed mountain; and this is the literal signification of the name.

17 The city of Mexico founded.

The city of Mexico was founded in the year 1325, in the most incommodious situation we can imagine, viz. on a small island named Tenochtitlan, in the middle of a great lake, without ground to cultivate for their subsistence, or even room sufficient to build their habitations. Their life was therefore as miserable here for some time as it had been when they were on the islands at the end of the lake, and they were reduced to the same shift to maintain themselves. To enlarge the boundaries of their island, they drove palisades into those parts of the water which were most shallow, terracing them with stones and turf, and uniting to their principal island several other smaller ones which lay in the neighbourhood. To procure to themselves afterwards stones, wood, &c. for constructing their habitations, as well as clothing and other necessaries, they instituted a commerce with the people who dwelt on the borders of the lake, supplying them with fish, waterfowl, and other more minute inhabitants of the lake and marshes, which they contrived to render eatable; and in return for all this they received the necessaries above mentioned. The greatest effort of their industry, however, was the construction of floating gardens, by means of bushes and the mud of the lake; and these they brought to such perfection that they produced maize, pepper, chia, French beans, and gourds.

18 The two factions separate.

For thirteen years that the Mexicans had to struggle with extreme difficulty, they remained at peace; but no sooner did they begin to prosper and live comfortably, than the inveterate enmity betwixt the two factions broke out in all its fury. This produced a separation; and one of the parties took up their residence on a small island at a little distance to the northward, which, from a heap of sand found there, they at first named *Xaltilolco*, but afterwards *Tlatelolco*, from a terrace constructed by themselves. This island was afterwards united to that of Tenochtitlan.

About this time the Mexicans divided their city into four parts, a division which still subsists; each quarter having now its tutelar saint, as it had formerly its tutelar god. In the midst of their city was the sanctuary of their great god *Mexitli*, whom they constantly preferred to all the rest. To him they daily performed acts

acts of adoration: but instead of making any progress in humanity, they seem to have daily improved in the most horrible barbarities, at least in their religion.

19 Monstrous barbarity of their religion.

The dreadful sacrifices made of their prisoners, could only be exceeded by that which we are now about to relate. Being now on a more respectable footing than formerly, they sent an embassy to the petty king of Colhuacan, requesting him to send them one of his daughters, that she might be consecrated the mother of their protecting god. The unsuspecting prince readily complied with their desire.—The unfortunate princess was conducted in great triumph to Mexico; but no sooner was she arrived, than she was sacrificed in a shocking manner; and, to add to the horror of the deed, the body was flayed, and one of the bravest young men of the nation dressed in her skin. Her father, ignorant of this dreadful transaction, was invited by the Mexicans to be present at the apotheosis of his daughter, and went to see the solemnity, and to worship the new divinity. He was led into the sanctuary, where the young man stood clothed in the bloody skin of his daughter; but the darkness of the place prevented him from seeing what was before him. They gave him a censer in his hand, and some copal to begin his worship; but having discovered by the flame of the copal the horrible spectacle, he ran out in a distracted manner, calling upon his people to revenge the injury; but this they were not able to do at that time nor ever after.

In the year 1352 the Mexican government was changed from an aristocracy to a monarchy. At first they were governed by 20 lords, of whom one had an authority superior to the rest. This naturally suggested the idea of monarchy; and to this change they were also induced by the contemptible state in which their nation still continued, thinking that the royal dignity would confer upon it a degree of splendour which otherwise it could not enjoy; and that by having one leader, they would be better able to oppose their enemies.

20 Acamapitzin the first king of Mexico.

Proceeding, therefore, to elect a king, the choice fell upon Acamapitzin, a man of great estimation among them, and descended from Opochtli, a noble Aztecan, and a princess of the royal family of Colhuacan. As he was yet a bachelor, they attempted to negociate a marriage, first with the daughter of the lord of Tacuba, and then of the king of Azcapozalco: but these proposals being rejected with disdain, they applied to Acolmiztli lord of Coatlichan, and a descendant of one of the three Acolhuan princes; who complied with their request, and the nuptials were celebrated with great rejoicings.

21 The Tlatelolcos also choose a king.

In the mean time, the Tlatelolcos, the natural rivals of the Mexicans, resolved not to be behind them in any thing which had the least appearance of augmenting the glory of their state. They likewise, therefore, chose a king; but not thinking proper to choose him from among themselves, they applied to the king of the Tepanecas, who readily sent them his son; and he was crowned first king of Tlatelolco in 1353. In this the Tlatelolcos seem to have had a design of humbling their rivals, as well as rendering themselves more respectable; and therefore it is probable that they had represented the Mexicans as wanting in that respect due to the Tepanecan monarch, as having elected a king without his leave, though at the same time they were tributaries to him. The consequence of this was, that he took a resolution to double their tribute.

22 Mexicans oppressed.

Hitherto they had paid only a certain number of fish and water-fowl; but now they were ordered to bring also several thousands of fir and willow plants to be set in the roads and gardens of Azcapozalco, and to transport to the court a great floating garden, which produced vegetables of every kind known in Anahnac. This being accomplished with great difficulty, the king commanded them next year to bring him another garden, with a duck and swan in it both sitting upon eggs; but so, that on their arrival at Azcapozalco the brood might be ready to hatch. This was also done; and the prince had the satisfaction of seeing the young birds come out of the eggs. The third year they were ordered to bring a live stag along with a garden. This was more difficult than any of the former tasks; because they were obliged, in order to hunt the stag, to go to the mountains of the continent, where they were in danger of falling into the hands of their enemies: however, this also was accomplished, and the desire of the king gratified.

In this manner the Mexicans were oppressed for no less than 50 years. They freed themselves, however, from all their difficulties by vigorous exertions, absurdly ascribing to the protection of that malevolent being whom they worshipped the glory of every deliverance. Acamapitzin governed this city, which at that time comprehended the whole of his dominions, for 37 years in peace. His queen being barren, he married another wife, but without abandoning the first; and these two, instead of being rivals to one another, lived together in the utmost harmony; the first wife taking upon herself the charge of educating *Huitzilihuitl*, the son of the second. He had, besides, several children by other women, and one named *Itzcoatl*, who afterwards proved one of the best and most renowned kings who sat on the throne of Mexico. He is said also to have conquered four considerable cities; but Clavigero thinks he must in this only have been an auxiliary, it being very improbable, that while he could scarce maintain his own territories, he should think of foreign conquests.

Acamapitzin died in 1389, greatly lamented by the Mexicans, and his death was followed by an interregnum of four months. As the deceased monarch had formerly resigned his authority into the hands of his nobles, it was necessary that a new election should take place; and when this was done, the choice fell upon Huitzilihuitl, the son of Acamapitzin.

23 Huitzilihuitl the second king.

As he was still unmarried, it was resolved, if possible, to procure him an honourable and advantageous match. With this view, a deputation of nobility was sent to the king of Azcapozalco, requesting, in very humble terms, an alliance with one of his daughters. The expressions made use of by these ambassadors are said by our author to have been particularly elegant in the Mexican language; but it is difficult to understand how a speech made among a people ignorant of the art of writing could be particularly recorded at the interval of some hundreds of years after. They are as follow: "We beseech you, with the most profound respect, to take compassion on our master and your servant Huitzilihuitl, confined among the thick rushes of the lake.—He is without a wife, and we without a queen.—Vouchsafe, Sir, to part with one of your jewels or most

most precious feathers. Give us one of your daughters, who may come to reign over us in a country which belongs to you."

24 Marries a daughter of the king of the Tepanecans.

This piece of oratory had such an effect upon the king, that he granted their request, and a Tepanecan princess was conducted in great triumph to Mexico, where the marriage was solemnized with the utmost joy. Though this princess brought him a son the first year of their marriage, the king, in order to strengthen himself by fresh alliances, married also the daughter of another prince, by whom he had Montezuma *Ilhuicamina*, the most celebrated of all the Mexican kings.

As the Mexicans advanced in wealth and power, so did their rivals the inhabitants of Tlatelolco.—Their first king died in 1399, leaving his subjects greatly improved in civilization, and the city much enlarged and beautified. The rivalship which subsisted between the two cities had indeed greatly contributed to the aggrandizement of both. The Mexicans had formed so many alliances by marriage with the neighbouring nations, had so much improved their agriculture and floating gardens on the lake, and had built so many more vessels to supply their extended commerce and fishing, that they were enabled to celebrate their secular year, answering to A. D. 1402, with greater magnificence than they had ever done since they left their original country of Atztlan.

25 Unfortunate reign of Techotlala's son.

All this time Techotlala, the son of Quinatzin, continued to reign in Acolhuacan, and for 30 years enjoyed uninterrupted tranquillity; but being now very far advanced in years, and finding his end approach, he called to him his son Ixtlilxochitl, and recommended to him to beware of the ambitious disposition of the king of Azcapozalco, as he was apprehensive that he might attempt something against the peace of the empire. His suspicions were verified; for on the death of Techotlala, which happened in 1406, the king of Azcapozalco, without making the usual submissions to the new king, to whom he was a feudatory, set out for his own territories, with a view to stir up the other feudatory princes to rebellion. Having called to him the kings of Mexico and Tlatelolco, he told them, that Techotlala, who had long tyrannized over that country, being dead, he designed to procure freedom to the princes, so that each might rule his own territory entirely independent of the king of Acolhuacan; but for this purpose he needed their assistance, and trusted to their well known spirit to take part with him in the enterprise. He informed them likewise, that in order to ensure success, he would find means to unite other princes in the confederacy.

The new king of Acolhuacan, in the mean time, was employed in settling the affairs of his kingdom, and endeavouring to gain the good will of his subjects. The combination against him was soon discovered: but though Ixtlilxochitl was desirous of heading his army in person, he was dissuaded from so doing by his courtiers; so that the conduct of the war was committed to his generals. To weaken the enemy, they ravaged the territories of six revolted states: but, notwithstanding this, and the superior discipline of the royal army, the war was carried on by the rebels with great obstinacy, their armies being constantly recruited by fresh troops in proportion to their losses. At last, after three years of a ruinous war, the king of Azcapozalco, finding that his resources would at last fail him, sued for peace; but with a design of accomplishing by treachery what he had not yet been able to do by force. His adversary, equally reduced with himself, consented to a peace, though he knew very well that the Tepanecan prince intended to observe it no longer than suited his purpose.

26 Chimalpopoca third king of Mexico.

In the year 1409 died Huitzilihuitl king of Mexico, who likewise left the right of electing a successor to the nobility. They made choice of his brother Chimalpopoca; and from thence it became an established law to choose one of the brothers of the deceased king, or, if he had no brothers, to elect one of his grandsons. While the new prince was endeavouring to secure himself on the throne, the treacherous Tezozomoc used all means in his power to strengthen the party he had formed against the king of Acolhuacan. In this he was attended with such success, that the unfortunate prince found himself reduced to the necessity of wandering among the neighbouring mountains, at the head of a small army, accompanied by the lords of Huexotla and Coatlichan, who remained always faithful to him. The Tepanecans distressed him to such a degree, by intercepting his provisions, that he was forced to beg them of his enemies.

27 Distress and death of the king of Acolhuacan.

One of his grandsons was sent to Otompan, a rebel state, to request them to supply their king with the provisions he stood in need of, and to exhort them to abandon the cause of the rebels, which they had espoused. No task could be more dangerous; yet such was the magnanimity of the young prince's disposition, that he readily set out on the journey; nor was he deterred by the information he got that there were in the place certain Tepanecans who had come on purpose to publish a proclamation from Tezozomoc. He went boldly to the most public place of the town, and in presence of those who published the proclamation made known his request. This heroism, however, did not meet with the success it deserved. His propositions were derided from the moment they were made; but the people did not offer any farther insult, until one of the meaner sort threw a stone at him, exciting others of the same stamp to put him to death. The Tepanecans, who had hitherto continued silent, perceiving their opportunity, joined in the general cry to kill the prince, and began also to throw stones. The prince attempted first to defend himself, and afterwards to escape by flight; but, both being equally impossible, he fell under a shower of stones. The Tepanecans, exulted in this act of treachery, and soon after cut off Ixtlilxochitl himself, after having treacherously persuaded him to a conference with two of their captains. This perfidious act was committed in sight of the royal army, who were too weak to revenge it; the royal corpse was saved with difficulty; and *Nezahualcojotl*, heir apparent to the crown, was obliged to shelter himself among the bushes from the fury of his enemies.

28 Acolhuacan conquered by Tezozomoc.

Tezozomoc having now in a great measure gained his point, proceeded to pour down his troops upon those cities and districts which had remained faithful to the late unfortunate monarch. The people made a most desperate defence, and killed vast numbers of their enemies; but at last being themselves reduced by the calamities of war, and in danger of total extermination, they were obliged to quit their habitations and

fly

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Prince Nezahualcojotl was present in disguise at this disposal of his dominions, along with several other persons of distinction who were enemies of the tyrant; and so much was he transported with passion, that it was with difficulty he could be restrained from killing Tezozomoc on the spot, though this would certainly have been done at the expence of his own life. All the rest of the Acolhuacan empire submitted; and Nezahualcojotl saw himself for the present deprived of all hopes of obtaining the crown.

29 His tyranny and death.

Tezozomoc had now attained the summit of his ambition: but instead of conciliating the minds of his new subjects, oppressed them with new taxes; and being conscious of the precarious situation in which he stood, and tormented with remorse on account of his crimes, fell into melancholy, and was constantly haunted with frightful dreams. He was now become so old, that his body no longer retained its natural heat. He was therefore obliged to be covered up with cotton in a great cradle, not being able to sit erect in a chair. In this miserable condition, however, he never forgot his tyranny or cruelty. From his cradle he issued oppressive laws relating to the Acolhuacans; and almost with his last breath renewed his commands with regard to Nezahualcojotl. At last he expired in the year 1422, leaving the crown to his son Tajatzin.

30 The throne usurped by Maxtlaton.

Tezozomoc was no sooner dead than Maxtlaton, without paying the least regard to his father's will, began to exercise the functions of a sovereign. Though it was the right of Tajatzin to invite to his father's funeral whom he pleased, Maxtlaton took that upon himself. Nezahualcojotl, though not invited, came among the rest; but though Teuctzintli, brother to Maxtlaton, insisted upon his being put to death, the latter opposed it, as it could not then be done privately, and he hoped to find another opportunity. No sooner were the funeral ceremonies over, however, than Maxtlaton behaved in such a manner to his brother Tajatzin, that the prince thought proper to retire to Chimilpopoca king of Mexico, to whom he had been particularly recommended by his father, in order to have his advice. This monarch, agreeable to the character of that age and people, advised him to invite his brother to an entertainment, and then murder him. Unluckily for them both, this discourse was overheard by a servant, who in expectation of a reward informed the tyrant of what he had heard: but instead of this, Maxtlaton, pretending to disbelieve his story, drove the informer from his presence with ignominy. Notwithstanding this pretence, the tyrant had not the least doubt of the truth of what was told him; and therefore determined to rid himself of his brother without delay. This he soon accomplished in the very same way that had been projected against himself. Tajatzin, along with the kings of Mexico, Tlatelolco, and some other feudatory princes, were invited by Maxtlaton to an entertainment. The king of Mexico prudently excused himself, but the unsuspecting Tajatzin fell into the snare. He came to the place of entertainment, and was instantly put to death. The company were greatly alarmed; but Maxtlaton, having explained to them his reasons for so doing, they not only excused him, but proclaimed him king; to which it is not to be doubted that their fears greatly contributed.

31 Tajatzin murdered.

32 Miserable fate of the king of Mexico.

Though the king of Mexico escaped a sudden death by his absence at this time, it was only to perish in a more slow and ignominious manner. The vengeance of Maxtlaton first appeared by sending him a woman's dress in return to the present he sent him as a feudatory; which being a reflection upon his courage, was the highest affront that could be offered him. This insult, however, was quickly followed by one of a much higher nature. Having heard that one of the Mexican prince's wives was an extraordinary beauty, he enjoined some Tepanecan ladies who were accustomed to visit that princess, to invite her to spend some days with them at Azcapozalco. This being complied with, the tyrant easily got an opportunity of ravishing her, and then sent her back to her husband. Chimilpopoca was so much affected by this misfortune, that he resolved to offer himself up a sacrifice to his god. Maxtlaton, however, was resolved that he should not have even this satisfaction. At the very time of the ceremony, therefore, he sent a body of troops; who entering Mexico without resistance, carried off the king alive, to the astonishment of the multitude; and who probably were so much confounded by this unexpected adventure, that they did not think of making any resistance.

Chimilpopoca being carried prisoner to Azcapozalco, was confined in a strong wooden cage, the common prison for criminals. Maxtlaton still was not satisfied: he wished to get into his hands Nezahualcojotl; and with this view sent a message to him, pretending that he was willing to come to an agreement with him respecting the kingdom of Acolhuacan. Though the prince was well assured of the tyrant's treacherous intentions, he went boldly to his palace, presented himself before him, and told him that he had heard of the imprisonment of the king of Mexico; he had heard also that he wished to take away his own life; he desired him to do so, and to gratify his malice. Maxtlaton was so struck with this speech, that he assured the prince he had not formed any design against his life, and that he neither had put to death the king of Mexico, nor would do so. He then gave orders for his being properly entertained, and even allowed him to pay a visit to the king of Mexico in prison. The unfortunate Chimilpopoca, after reciting his misfortunes, requested the prince not to return to court, where they would certainly fall upon some project for taking away his life; and having pathetically recommended to him the care of his subjects, made him a present of a gold pendant and some other jewels he wore; after which they took a last farewell.

33 He is visited in prison by Nezahualcojotl.

34 Itzcoatl raised to the throne of Mexico, who assists Nezahualcojotl.

In the mean time, the Mexicans raised to the throne Izcoatl, the son of Acamapitzin by a slave, and who was accounted the most prudent, just, and brave, of all the Mexican nation. His election was no less pleasing to Nezahualcojotl and his party, than it was offensive to Maxtlaton. An alliance was quickly concluded between

between the exiled prince and the king of Mexico; and this was soon followed by the commencement of hostilities on the part of the former. His first enterprize was against the city of Tezcuco, which he determined to take by assault, but was prevented by the submission of the inhabitants. He put to death, however, all the officers established by the tyrant; and all the Tepaneeans he found there. The very same day another large city named Acolman was furiously attacked by a detachment of his army; great numbers put to the sword, and among the rest the governor, who was brother to Maxtlaton; and the same day also Coatlichan was taken by the Chalcese.

The Mexican monarch, hearing of the successes of his ally, sent an embassy to congratulate him upon them. His ambassador was a son of king Huitzilihuitl, named *Montezuma*, who for his invincible courage and great qualities was surnamed the *man of great heart and the archer of heaven*. The journey was extremely dangerous; but Montezuma undertook it without any fear, accompanied by another nobleman. They got in safety to the place where the prince was; but had the misfortune to be taken prisoners, and were carried to Chalco; the lord of which city, named Toteotzin, was an inveterate enemy to the Mexicans. By him he was immediately put in close confinement, under the care of one Quateozin, who was inviolably attached to the Mexican interest. Orders were given to the latter to provide no sustenance for the prisoners but what was prescribed by his lord, until the mode of death which they were to suffer should be determined. Toteotzin then sent his prisoners to them, that they might be sacrificed there if they thought proper. These people, however, rejected the proposal with disdain; on which Toteotzin, thinking to regain the favour of Maxtlaton, informed him of the prisoners he had in his possession. But Maxtlaton called him a double-minded traitor, and commanded him instantly to set the prisoners at liberty. Before this answer arrived, however, Quateozin had instructed the prisoners how to make their escape, and directed them also not to return by land lest they should again be intercepted, but to embark at a certain place, and proceed by water to Mexico. They followed his advice exactly; and having got to the place to which they were directed, arrived safely at their city, to the great surprise and joy of the inhabitants.

35 Dangerous embassy undertaken by Montezuma.

Toteotzin, enraged at the loss of his prisoners, put Quateozin to a cruel death, destroying also all his family excepting one son and a daughter; of whom the latter fled to Mexico, where she was highly honoured on her father's account. Maxtlaton, too, notwithstanding his generosity to the prisoners (which Clavigero derives from mere opposition to Toteotzin), prepared to wage a formidable war with the Mexicans, who had agreed to unite their troops with those of the prince. The Mexican populace, terrified at engaging so powerful an enemy, demanded that their king should submit and beg for peace. So great was the tumult, that the king himself was obliged to consent; and it required the utmost exertions of Montezuma's eloquence to persuade the people to agree to a commencement of hostilities. This being done at last, the king next called together the chief nobility, and asked which of them would have the courage to carry an embassy to the king of the Tepanecans? This adventure appeared so hazardous, that all of them kept a deep silence, until Montezuma declared himself willing to undertake the arduous enterprise. He was ordered to propose peace to Maxtlaton, but to accept of no dishonourable conditions; to which he punctually adhered. Maxtlaton refused to give any immediate answer, but promised to give one next day, after he had consulted his nobility. Montezuma, dreading some treachery if he staid all night, promised to return next day; which he did, and was told that Maxtlaton had determined upon war. Montezuma then performed the ceremony of challenging him, by presenting him with certain defensive weapons, anointing his head, and fixing feathers upon it, as was customary to do with dead persons. Lastly, He protested, in the name of his master, that as Maxtlaton would not accept of the offered peace, he and all the Tepanecans would infallibly be ruined. Maxtlaton showed not the least sign of displeasure, but gave Montezuma arms in like manner to present to the king of Mexico; and directed him, for his personal security, to return in disguise through a small outlet from the palace. Montezuma followed his advice; but as soon as he found himself out of danger, began to insult the Tepanecan guards; and though they rushed violently upon him, he not only escaped from their attack, but killed one or two of them.

36 Maxtlaton declares war against Mexico.

On his return to Mexico, the populace were again thrown into the utmost consternation by the news that war was inevitable, as the chiefs of the two nations had challenged one another. They now requested the king to allow them to retire from their city, of which they supposed the ruin to be certain. The king encouraged them with the hopes of victory. "But if we are conquered (replied they), what will become of us? "If that happens (answered the king), we are that moment bound to deliver ourselves into your hands, to be made sacrifices at your pleasure." "Be it so (replied they), if we are conquered; but if we obtain the victory, we and our descendants are bound to be tributary to you; to cultivate your lands and those of your nobles; to build your houses; and to carry for you, when you go to war, your arms and baggage."

37 He is defeated and killed.

Matters being thus settled, intelligence was sent to Prince Nezahualcojotl to repair with his army to Mexico, which he did without delay; and the day after his arrival a furious engagement took place. The Tepanecan army was commanded by a general named *Mazatl;* Maxtlaton himself not judging it proper to quit his capital. The soldiers on both sides fought with the utmost bravery; but towards night the Mexicans, disheartened by seeing the army of their enemies continually increasing in number, began once more to lose their courage and talk of surrendering. The king, greatly concerned, asked Montezuma what should be done to dissipate the fears of the people? That brave prince replied, that they must fight till death; that if they died with their arms in their hands, it would be honourable; but to survive their defeat, would be eternal ignominy. Nothing could be more salutary than this advice at so critical a juncture: for the Mexicans were already begun to implore the mercy of their enemies, and to promise to sacrifice their chiefs, whose ambition had brought the whole nation into

History. into such a dilemma. On hearing this, the whole body of nobility, with the king and Montezuma, at their head, assaulted the enemy so furiously, that they repulsed them from a ditch of which they had taken possession; after which, Montezuma, happening to encounter Mazatl the Tepanecan general, struck him such a blow on the head that he fell down lifeless. Thus the Mexicans were inspired with fresh courage, and their enemies proportionally dispirited: however, they retired for that night to the city, in some hopes of being able to retrieve their fortune next day. Maxtlaton encouraged them by every method in his power; but fortune proved still more unfavourable than the day before. The Tepanecans were now entirely defeated, and the city of Azcapozalco taken. Maxtlaton, who seems not to have had the courage to fight, had not now the presence of mind to fly. He attempted indeed to hide himself; but being quickly discovered, he was beaten to death with sticks and stones. The city was plundered, the inhabitants butchered, and the houses destroyed by the victors.

38 he Tepa- ecans en- irely re- uced. This victory proved decisive in favour of the confederates. Every other place of strength in the country was quickly reduced, until the Tepanecans, finding themselves on the verge of destruction, sent an humble embassy to the king of Mexico, requesting to be taken under his protection, and to become tributaries to him. Itzcoatl received them graciously; but threatened them with total extirpation if they violated the fidelity they had sworn to him.

Itzcoatl, after this extraordinary success, took care to have the above-mentioned contract ratified between the nobility and common peole, by which the latter were bound to perpetual services. Those who had discouraged the soldiers in time of battle were banished for ever from the state of Mexico; while Montezuma and others who had distinguished themselves by their bravery, were rewarded with lands, as was usual with other conquerors.

39 ezahual- ojotl made ing of A- olhuacan. Itzcoatl, now finding himself firmly seated on the throne of Mexico, set about performing his engagements to the Acolhuacan prince, by seating him on the throne of his ancestors. Having again joined their armies, they marched against Huaxotla, a city which refused to submit, even though terms of pardon were offered them. Instead of this, they rashly ventured a battle, in which they were entirely defeated; and were then fain to send a deputation of their old men, pregnant women, &c. as was customary in cases of distress, to move the enemy to compassion. At last all obstacles being removed, Nezahualcojotl was seated on the threne of Acolhuacan, the auxiliary troops were dismissed, and Itzcoatl left at liberty to pursue his conquests, in which he was still assisted by the king of Acolhuacan. The first expedition was against Cojohuacan, and other two Tepanecan cities, who had not only refused submission themselves, but excited others to shake off the yoke al-

40 onquests the lexicans. so. The war against them proved bloody. Three battles were fought, in which Itzcoatl gained no other advantage than making the enemy retreat a little; but in the fourth, while the two armies were hotly engaged, Montezuma, with a body of chosen troops, which he had placed in ambuscade, attacked the rear-guard of the rebels with such vigour, that they were soon disordered, and obliged to fly to the city. The conquerors pursued them thither; and Montezuma perceiving that they intended to fortify themselves in the greater temple, frustrated their design by getting possession of it and burning the turret. By this disaster they were so much terrified, that they fled to the mountains south of Cojohuacan; but even there the royal army overtook and pursued them more than 30 miles, till they came to another mountain, where, quite exhausted with fatigue, and seeing no means of escape, they were obliged to surrender at discretion.

Having thus happily accomplished the conquest of Cojohuacan and the other rebellious cities, the two kings returned to Mexico. Itzcoatl gave great part of the Tepanecan country, with the title of king of *Tacuba*, to *Totoquihuatzin*, a grandson of Tezozomoc, but who does not appear to have been any way concerned in his projects against the Mexicans. An alliance was then formed among the three kings on the following terms: The king of Tacuba held his crown on condition of serving the king of Mexico with all his troops, at any time when required; for which he was to have a fifth part of the spoils taken from the enemy. 41 Alliance between the kings of Mexico, Acolhuacan, and Tepaneca. The king of Acolhuacan was likewise to assist the king of Mexico in war; and for this he was to have a third part of the plunder, after deducting the share of the king of Tabuca; and the remainder was to belong to the king of Mexico. The kings of Tacuba and Acolhuacan, were both declared honorary electors of the kings of Mexico; the real electors being four nobles: and the king of Mexico was likewise bound to assist in the wars of his allies whenever it was demanded.

After having thus settled matters among themselves, and rewarded their soldiers, Itzcoatl set out with Nezahualcojotl for Tezcuco, where the Acolhuacan king was crowned with all possible ceremony. Here the new king took every method which prudence could suggest to establish his authority on a permanent basis; but while he was thus employed, the Xochimilcas, fearing lest the Mexicans might conquer their country as they had done that of the Tepanecans, held a council on what was to be done to prevent such a disgrace. In this council it was determined to commence hostilities against that rising state, before it should become more formidable by new conquests. Itzcoatl was no sooner informed of this determination, than he sent Montezuma with a great army against them. 42 Other conquests. The Xochimilcas met him with one still more numerous; but being worse disciplined, they were quickly defeated, and their city taken in a very short time after. This conquest was followed by the reduction of Cuitlahuac, situated on a small island in the lake of Chalco. Their insular situation gave them confidence to atack the formidable power of the Mexicans. The king was so sensible of the difficulty of this enterprise, that he proposed to attack them with the whole force of the alliance: Montezuma, however, with only a small number of men of his own training, whom he furnished with proper vessels, reduced them in seven days.

43 Montezuma I. king of Mexico. Itzcoatl died in the year 1436, at a very advanced age, in the height of prosperity, and was succeeded by Montezuma I. the greatest monarch that ever sat on the Mexican throne. Before his coronation, in order to comply with the barbarous rites of his religion,

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gion, he made war upon the Chalcese, in order to procure the prisoners who were to be sacrificed at his coronation; and scarce was this ceremony over, when a new war commenced, which terminated in the destruction of that city. This quarrel happened between the Chalcese and the Tezcucans. Two of the royal princes of Tezcuco having gone a-hunting on the mountains which overlook the plains of Chalco, while employed in the chase, and separated from their retinue, with only three Mexican lords, fell in with a troop of Chalcese soldiers; who, to gratify the cruelty of their master, carried them all prisoners to Chalco. The cruel and inconsiderate tyrant who commanded there instantly put them all to death: after which he caused their bodies to be salted, dried, and placed in an hall of his palace, where they served as supporters to the pine torches burned there for lights every evening. The king of Tezcuco, overwhelmed with grief, and to the last degree exasperated at such an inhuman act, called for the assistance of the allied kings. The city was attacked at once by land and water. The inhabitants, knowing that they had no mercy to expect, fought like men in despair. Even the old tyrant who commanded them, though unable to walk, caused himself to be carried in a litter among the combatants; notwithstanding which they were totally defeated, and the most severe vengeance executed upon them.

44 Chalco taken.

Montezuma, on his return, found himself obliged to encounter an enemy more formidable on account of his vicinity, than more powerful ones at a distance. This was the king of Tlatelolco, who had formerly conspired against the life of Itzcoatl; and finding himself disappointed in this, had tried to reduce his power by entering into a confederacy with some of the neighbouring lords. At that time his designs proved abortive, but he resumed them in the time of Montezuma; the consequence of which was, that he was defeated and killed. One *Moquihuix* was chosen in his room; in whose election it is probable that Montezuma had a considerable share. This was followed by conquests of a much more important nature. The province of *Cuihixcas*, lying to the southward, was added to his dominions, comprehending a tract of country more than 150 miles in breadth; then, turning to the westward, he conquered another named *Tzompahuacan*. This success, however, was for a short time interrupted by a war with Atonaltzin, lord of a territory in the country of the Mixtacas. This prince, puffed up on account of the great wealth he possessed, took it into his head that he would allow no Mexican to travel through his country. Montezuma sent ambassadors to know the reason of such strange conduct; but Atonaltzin gave them no other answer than showing them some part of his wealth, making a present to the king, and desiring them from thence to observe how much the subjects of Atonaltzin loved him; and that he willingly accepted of war, which was to determine whether he should pay tribute to the Mexicans or the Mexicans to him. Montezuma having informed his allies of this insolent answer, sent a considerable army against Atonaltzin, but had the mortification to be informed of its defeat; in consequence of which the pride of Atonaltzin was increased to a great degree. Montezuma, greatly chagrined at this first check, determined to head his next army in person; but before he could call together another, Atonaltzin had drawn into a confederacy with him the Huexotzincas and Tlascalans, who were glad of the opportunity, as they supposed, of reducing the power of the Mexicans. Their numbers, however, availed but little; Montezuma in the very first engagement totally defeated the confederate army. The allies of Atonaltzin were particularly unfortunate; for such of them as were not killed in the field of battle, were destroyed by their own party out of revenge for the unfortunate event of the battle.

45 Tlatelolco reduced, and Moquihuix made king.

46 Atonaltzin defeated, and the Mexican dominions enlarged.

By this victory the Mexican monarch became master not only of the dominions of Atonaltzin, but of many other neighbouring princes, against whom he made war on account of their having put to death some Mexican merchants or couriers without any just cause. The conquest of *Cuetlachtlan* or *Cotasta*, however, which he attempted in 1457, proved a much more difficult task. This province lies on the coast of the Mexican gulf, and had been formerly inhabited by the Olmecans, whom the Tlascalans had driven out. The inhabitants were very numerous; but dreading the power of Montezuma, called in those of Tlascala, together with the Huexotzincas, to their assistance. Along with these the allies drew the Cholulans also into the confederacy; so that this seems to have been the most formidable combination that had yet been formed against the Mexican power. Montezuma collected an excellently equipped army; which, however, he did not on this occasion command in person. It contained a great number of persons of very high rank, among whom were three princes of royal blood, and *Moquihuix* king of Tlatelolco already mentioned. The combination of the three republics against Mexico was not known at court when the army set out; but Montezuma, being informed of it soon after, sent an order to his generals to return. This accorded so ill with the romantic notions of valour entertained by the Mexicans, that a consultation of the generals was held whether they should obey it or not. At last it was determined that the king's order should be obeyed; but no sooner was this agreed to than Moquihuix accused them all of cowardice, and threatened, with his own troops, unassisted, to go and conquer the enemy. His speech had such an effect upon them all, that they went to meet the confederates. The Cotastese fought with great valour, but were unable to resist the royal forces; and their allies were almost totally destroyed. Six thousand two hundred of them were taken prisoners, and soon after sacrificed to the Mexican god of war in the barbarous manner already described. The victory was said to have been owing principally to the valour and good conduct of Moquihuix, insomuch that to this day a song made in his praise on that occasion is known in Mexico. Montezuma was so well pleased with the victory, that he not only forgave the disobedience of his orders, but bestowed upon Moquihuix a princess, one of his own cousins, to wife.

47 Inundation and famine at Mexico.

During the reign of this great monarch a violent inundation happened in Mexico. The lake, swelled by the excessive rains which fell in the year 1446, poured its waters into the city with so much violence that many

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many houses were destroyed, and the streets inundated to such a degree that boats were everywhere made use of. The inundation was soon followed by a famine. This was occasioned by the stinting of the crop of maize in 1448; the ears while young and tender being destroyed by frost. In 1450 the crop was totally lost for want of water; and in 1451, besides the unfavourable seasons, there was a scarcity of seed. Hence, in 1452, the necessities of the people became so great, that they were obliged to sell themselves for slaves in order to procure subsistence. Montezuma permitted them to go to other countries for support; but being informed that many sold themselves for a few days provision, he ordered, by proclamation, that no woman should sell herself for less than 400 ears of wheat, nor any man for less than 500. He opened also the public granaries for the relief of the lower classes; but nothing was able to stop the progress of the famine.

48 Axayacatl succeeds Montezuma.

Montezuma was succeeded by Axayacatl, who like his predecessor instantly commenced a war, for no other reason than that he might have prisoners to sacrifice at his coronation. He pursued Montezuma's plan of conquest; in which, however, he was less successful, many of the provinces reduced by that monarch having revolted after his death, so that it was necessary to reconquer them. On his returning successful from one of these expeditions, he built a new temple, to which he gave the name of *Coatlon;* but the Tlatelolcos, whose ancient rivalship seems to have revived on the death of Montezuma, built another in opposition, which they called *Coaxolotl.* Thus the former hatred between the two nations was renewed, and a discord took place which ended in the ruin of the Tlatelolcos.

49 Death of the kings of Acolhuacan and Tacuba.

The Mexicans sustained an irreparable loss in 1469 and 1470 by the death of their allies the kings of Tacuba and Acolhuacan.

The king of Tacuba was succeeded by his son Chimalpopoca, and the Acolhuacan monarch by his son Nezahualpilli. A short time after the accession of the latter, the war broke out between the Tlatelolcos and Mexicans, which ended in the destruction of the former. King Moquihuix had been married by Montezuma to a sister of Axayacatl, now on the throne of Mexico; but it appears that this princess never was greatly the object of his affection. On the contrary, he took all methods of expressing his dislike, either out of enmity to herself, or envy of the superior greatness of her brother. Not content with this, he entered into an alliance with a great number of the neighbouring states, in order to reduce the Mexican greatness. His wife, however, being informed of this scheme, communicated the particulars to her brother; and soon after, being impatient of the ill usage she received, came to Mexico with her four sons to claim the protection of her brother. This uncommon accident exasperated the Mexicans and Tlatelolcos against each other to such a degree, that wherever they met, they fought, abused, and murdered each other. The king of Tlatelolco prepared for war with many horrid ceremonies, of which the drinking of human blood was one. A day was appointed for attacking Mexico. Xiloman, lord of Colcuacan, was to begin the attack, afterwards to pretend flight, in order to induce the Mexicans to follow him; after which the Tlatelolcos were to fall upon their rear.

50 Tlatelolcos subdued, and the king killed.

For some reason, however, with which we are not acquainted, the Tlatelolcos began the attack without waiting for Xiloman; the consequence of which was, that he retired in disgust, leaving them to finish their battle the best way they could. The engagement lasted till night, when the Tlatelolcos were obliged to retire. Axayacatl, during the night, disposed of his troops in all the roads which led to Tlatelolco, appointing them to meet in the market-place. The Tlatelolcos, finding themselves attacked on all sides, retired gradually before the Mexicans, until at last they were forced into the market-place, where they found themselves worse than ever on account of its narrowness, which did not allow them room to act. The king stood on the top of the great temple, encouraging his men to exert themselves against the enemy. His words, however, had now lost their usual influence. He not only was not obeyed, but was reproached with cowardice because he did not come down and fight among the rest. At last the Mexicans arrived at the temple, and ascended to the balcony where the king was. He made a desperate defence for a little; but by a violent push in the breast was thrown backwards upon the steps of the temple, and stunned or perhaps killed by the fall.

The Tlatelolcos being thus reduced, Axayacatl next set out on an expedition against the Matlazincas, a tribe in the vale of Toluca, who still refused to submit to the Mexican yoke. Having proved successful in this expedition, he undertook to subdue also the northern part of the valley, now called *Valle d' Ixtlahucan*, particularly *Xiquipilco*, a considerable city and state of the Otomies, whose chief was much renowned for strength and bravery. Axayacatl, who likewise valued himself on these qualites, encountered him in single combat. In this, however, he was overmatched, and received a violent wound in the thigh; after which he would have been taken prisoner, had not some young Mexicans made a desperate effort for his rescue. Notwithstanding this disaster, Axayacatl's army gained a complete victory, carrying off 11,060 prisoners among whom was the chief of the Otomies himself, and two of his officers who had attacked the king. These chiefs were put to death at an entertainment of the allied kings, the sight of their agonies not interrupting in the least the mirth of the feast; so much were they familiarized to the shedding of human blood.

51 Axayacatl wounded and in great danger.

He was succeeded by his elder brother Tizoc. He intended to have built a larger temple than any that had yet been seen in Mexico, though that originally built had been greatly enlarged by some of his predecessors. For this purpose he collected a great quantity of materials; but before he could bring his projects to bear, he was taken off by a conspiracy of his subjects. During the reign of Tizoc, the Acolhuacans made war upon the Huexotzincas, ruined their city, and conquered their territory. Nezahualpilli also, the Acolhuacan monarch, though he had already several wives, had not made any of them queen, having wished to confer that honour upon one of the royal family of Mexico. Tizoc readily gave him one of his grand-daughters, who had a sister of singular beauty named *Xocotzin*. The friendship betwixt these two ladies was such, that the one could

52 Is succeeded by Tizoc.

History. not think of being separated from the other; for which reason the new queen sought and obtained permission to take her sister along with her to Tezcuco. Xocotzin had not been long there before the king fell in love with her, and married her with the title of queen likewise. Soon after this second marriage, the first queen brought forth a son named *Cacamatzin*, who succeeded him in the throne, and was afterwards taken prisoner by the Spaniards.

53
Ahuitzotl dedicates a temple with a multitude of human victims.

Ahuitzotl, the brother of Tizoc, succeeded him in the kingdom of Mexico. His first object was to finish the great temple begun by his predecessor; and such was the number of workmen, that it was completed in four years. During the time that it was building, the king employed himself in making war with different nations, reserving all the prisoners he took for victims at the dedication of the temple. The number of prisoners sacrificed at this dedication is said by Torquemada to have been 72,324; by other historians 64,060. The miserable victims were ranged in two files, each a mile and a half in length, terminating at the temple. The same year another temple was built by a feudatory lord, in imitation of the great one built by the king; at the dedication of which a vast number of prisoners were also sacrificed. These temples were dedicated in 1486. In 1487 happened a violent earthquake; and Chimalpopoca king of Acolhuacan died, who was succeeded by Totoquihuatzin II.

Ahuitzotl died in 1502, of a disorder produced by a contusion in his head. At the time of his death, the Mexican empire was brought to its utmost extent. His successor, Montezuma *Xocojotzin* or Montezuma *Junior*, was a person of great bravery, besides which he was likewise a priest, and held in great estimation on account of his gravity and the dignity of his deportment. His election was unanimous; and the nobles congratulated themselves on the happiness the country was to enjoy under him, little thinking how short the duration of their happiness or of their empire was to be.

54
Montezuma.

The first care of the new monarch, as usual, was to procure victims for the barbarous sacrifices to be made at his coronation. The people of Atlixco, who had again shaken off the Mexican yoke, were the sufferers on this occasion, being once more reduced, though not without great loss on the part of the Mexicans, some of whose bravest officers perished in the war. The ceremony of coronation was performed with such pomp as had never been seen before in Mexico; but no sooner was this ceremony over than Montezuma began to discover a pride which nobody had suspected before. All his predecessors had been accustomed to confer offices upon persons of merit, and those who appeared the most able to discharge them, without any partiality as to birth or wealth. Montezuma, however, disapproved of the conduct of his predecessors, under pretence that the plebeians should be employed according to their rank; for that in all their actions the baseness of their birth and the meanness of their education appeared: and in consequence of this maxim he deprived all the commoners of the offices they held about the court, declaring them incapable of holding any for the future. All the royal servants now were people of rank. Besides these who lived in the palace, 600 feudatory lords and nobles came to pay court to him. They passed the whole day in the antichamber, where none of their servants were permitted to enter; conversing in a low voice, and waiting the orders of their sovereign.—The servants of these lords were so numerous that they occupied three small courts of the palace, and many waited in the streets.

55
Magnificence displayed in his palace.

In every respect Montezuma kept up, as far as was possible, an extravagant appearance of dignity. His kitchen utensils were of the finest earthen ware, and his tablecloths and napkins of the finest cotton; but none of these ever served the emperor more than once, being immediately made a present of to some nobleman. The vessels in which his chocolate and other drinks from cocoa were prepared, were all of gold, or some beautiful sea-shell, or naturally-formed vessels, curiously varnished. He had also gold plate, but it was used only on particular occasions in the temple. The number and variety of his dishes astonished the Spaniards. He took great delight in the cleanliness of his own person, and of every thing about him. He bathed regularly every day, and had baths in all his palaces. Every day he wore four dresses, never using again those which he had put off, but reserving them as largesses for the nobility, or those who had distinguished themselves in war. The expence of all this rendered him very disagreeable to a great number of his subjects; though others were pleased with the readiness he showed to relieve the necessities of individuals, and his generosity in rewarding his generals and ministers who deserved it. Among other actions worthy of imitation, he appointed the city of Colhuacan as an hospital for all invalids, who after having faithfully served the crown either in the civil or military line, required a provision on account of their age and infirmities. In this place they were maintained and attended at the expence of the king.

56
His unsuccessful war with Tlascala.

The reign of Montezuma, even before the arrival of the Spaniards, was far from being so glorious with regard to his successes in war as those of his predecessors had been. He reduced indeed one rebellious province, and conquered another which had never before been subjugated; but in his war with Tlascala he was by no means successful. This was but a small republic at no great distance from the capital, but the inhabitants were remarkable for their bravery and independent spirit. The neighbouring states, however, who had been reduced by the Mexicans, envious of their liberty and prosperity, exasperated the Mexicans against them, by representing that the Tlascalans were desirous of making themselves masters of the maritime provinces on the Mexican gulf, and that by their commerce with these provinces they were increasing their wealth and power, and gaining the hearts of the people with whom they were to traffic. In consequence of this representation, strong garrisons were placed on the frontiers of Tlascala, to obstruct the commerce of the inhabitants, and thus to deprive them of the means of obtaining some of the necessaries of life. The Tlascalans complained; but received no other answer than that the king of Mexico was lord of all the world, and that the Tlascalans must submit and pay tribute to him. The Tlascalans returned a spirited answer to this insolent speech, and began to fortify their frontier. They had already enclosed all the lands of the repu-

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blic with intrenchments; and to these they now added a wall of six miles in length on the west side, where an invasion was most to be apprehended; and so well did they defend themselves, that though they were frequently attacked by the neighbouring states in alliance with Mexico, or subject to it, not one of them was able to wrest a foot of ground from them. Thus a continual series of wars and engagements took place between the states of Mexico and this republic, which continued till the arrival of the Spaniards.

57 Apprehensions entertained by the Mexicans of the arrival of a new people.

During the remainder of Montezuma's reign the empire was disturbed by various rebellions, of which the accounts are not sufficiently interesting to merit a particular detail; but in the year 1508, Montezuma began to entertain apprehensions of that fatal event which at length overtook him. An expedition having been undertaken against a very distant region named Amatla, the army in marching over a lofty mountain were attacked by a furious north wind, accompanied with snow; which made great havock in the army, many of them perishing with cold, and others being killed by the trees rooted up by the wind. The remains of the army continued their march to Amatla, where they were almost all killed in battle. By this and other calamities, together with the appearance of a comet, the Mexicans were thrown into the utmost consternation. Montezuma was so terrified by these omens, that having in vain consulted his astrologers, he applied to the king of Acolhuacan, who was reported to be very skilful in divination. Nezahualpilli having conferred with him upon the subject, told Montezuma that the comet presaged some calamity which was about to befal their kingdoms by the arrival of a new people: but this being unsatisfactory to the emperor, the king of Acolhuacan challenged him to a game at foot-ball, staking the truth of his prediction on the issue of the game. Montezuma lost the game, but did not yet acquiesce in the truth of his prediction. He therefore applied to a celebrated astrologer, whom it seems he had not yet consulted; but he confirmed the interpretation of Nezahualpilli: for which the emperor caused his house to be pulled down, and himself buried in the ruins.

58 Conquest of Mexico undertaken by Cortes.

Mexico itself was first discovered, though imperfectly, by a Spaniard named *Nunez de Balboa;* but in 1518 the conquest of it was undertaken by a celebrated adventurer named *Ferdinando Cortes.* On the 10th of February 1519, he set sail from the Havannah in Cuba; and soon landed on the island of Cozumel, on the coast of Yucatan, discovered the preceding year. Here he joined one of his officers named *Pedro d'Alvaredo*, who had arrived some days before, and collected some booty and taken a few prisoners. But the general severely censured his conduct; and the prisoners were dismissed, after they had been informed by an Indian interpreter named *Melchior*, that such injuries were entirely disagreeable to the intentions and wishes of Cortes. Here he mustered his army, and found that it amounted to 508 soldiers, 16 horsemen, and 109 mechanics, pilots, and mariners. Having encouraged his men by a proper speech, and released, by means of some Indian ambassadors, a Spaniard named *Jerom de Aguilar*, who had been detained a prisoner for eight years, he proceeded to the river Tabasco, where he hoped to be received in a friendly manner, as one Grijalva had been a short time before; but, from some unknown cause, he was violently attacked by them: however, the superiority of the Spanish arms soon decided the victory, and the inhabitants were obliged to own the king of Castile as their sovereign.

The Spaniards then continued their course westward, to the harbour of St Juan de Ullua; where they were met by two Mexican canoes, which carried two ambassadors from the emperor of that country, and showed the greatest signs of peace and amity. Their language was unknown to Aguilar; but one of the female prisoners above mentioned understood it, and translated it into the Yucatan tongue; after which Aguilar interpreted the meaning in Spanish. This slave was afterwards named *Donna Marina*, and proved very useful in their conferences with the natives.

59 State of the empire at that time.

At this time the Mexican empire, according to Dr Robertson, was arrived at a pitch of grandeur to which no society had ever attained in so short a period. Though it had subsisted only for 130 years, its dominion extended from the north to the south sea, over territories stretching about 500 leagues from east to west, and more than 200 from north to south; comprehending provinces not inferior in fertility, population, and opulence, to any in the torrid zone.—Though by nature Montezuma possessed a good deal of courage and resolution; yet from the first moment that the Spaniards appeared on his coast, he discovered symptoms of timidity and embarrassment, and all his subjects were embarrassed as well as himself. The general dismay which took place on this occasion was partly owing to the strange figure the Spaniards made, and the prodigious power of their arms; but partly also to the following circumstance. An opinion prevailed almost universally among the Americans, that some dreadful calamity impended over their heads, from a race of formidable invaders who should come from regions towards the rising sun, to overrun and desolate their country.

By means of his two interpreters, Donna Marina and Aguilar, Cortes learned that the chiefs of the Mexican embassy were deputies from Pilpatoe and Teutile; the one governor of a province under the emperor, and the other the commander of all his forces in that province: the purport of their embassy was to inquire what his intentions were in visiting their coasts, and to offer him what assistance he might need in order to continue his voyage. Cortes, in his turn, also professed the greatest friendship; and informed the ambassadors, that he came to propose matters of the utmost consequence to the welfare of the prince and his kingdom; which he would more fully unfold in person to the governor and the general. Next morning, without waiting for any answer, he landed his troops, his horses, and his artillery; began to erect huts for his men, and to fortify his camp.

60 Cortes lands and fortifies his camp.

The next day the ambassadors had a formal audience; at which Cortes acquainted them, that he came from Don Carlos of Austria, king of Castile, the greatest monarch of the east, and was intrusted with propositions of such moment that he would impart them to none but the emperor himself, and therefore required to be conducted immediately to the capital. This demand produced the greatest uneasiness; and

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61 The Indians endeavour to dissuade him from going to the capital, but in vain.

and the ambassadors did all in their power to dissuade Cortes from his design, endeavouring to conciliate his good will by the presents sent him by Montezuma. These they introduced with great parade, and consisted of fine cotton cloth, of plumes of various colours, and of ornaments of gold and silver to a considerable value, the workmanship of which appeared to be as curious as the materials were rich. But these presents served only to excite the avidity of the Spaniards, and to increase their desire for becoming masters of a country which abounded with so many precious commodities. Cortes indeed could scarcely restrain himself so far as to hear the arguments made use of by the ambassadors to dissuade him from going to the capital; and, in a haughty, determined tone, insisted on his former demand of being admitted to a personal interview with their sovereign.

During this conversation, some painters in the retinue of the Mexican chiefs had been diligently employed in delineating, upon white cotton cloths, figures of the ships, horses, artillery, soldiers, and whatever else attracted their eyes as singular.

62 Montezuma made acquainted with his design.

While exerting their utmost efforts in representing all these wonderful things, messengers were immediately despatched to Montezuma with the pictures, and a full account of every thing that had passed since the arrival of the Spaniards, together with some European curiosities to Montezuma; which Cortes believed would be acceptable on account of their novelty. The Mexican monarchs had couriers posted at proper stations along the principal roads; and as these were trained to agility by a regular education, they conveyed intelligence with surprising rapidity. Though the city in which Montezuma resided was above 180 miles from St Juan de Ullua, Cortes's presents were carried thither, and an answer returned to his demands, in a few days. As the answer was unfavourable, Montezuma had endeavoured to mollify the Spanish general by the richness of his presents. These consisted of the manufactures of the country; cotton stuffs so fine, and of such delicate texture, as to resemble silk; pictures of animals, trees, and other natural objects, formed with feathers of different colours, disposed and mingled with such skill and elegance as to rival the works of the pencil in truth and beauty of imitation. But what chiefly attracted their attention, were two large plates of a circular form; one of massive gold representing the sun, the other of silver representing the moon. These were accompanied with bracelets, collars, rings, and other trinkets of gold; and that nothing might be wanting which could give the Spaniards a complete idea of what the country afforded, some boxes filled with pearls, precious stones, and grains of gold unwrought, as they had been found in the mines or rivers, were sent along with the rest. Cortes received all with an appearance of the most profound respect for Montezuma; but when the Mexicans, presuming upon this, informed him, that their master, though he desired him to accept of what he had sent as a token of his regard for the prince whom he represented, would not give his consent that foreign troops should approach nearer to his capital, or even allow them to continue longer in his dominions, Cortes declared in a manner more resolute and peremptory than formerly, that he must insist on his first demand; as he could not, without dishonour, return to his own sovereign until he was admitted into the presence of the prince whom he was appointed to visit in his name.

63 Sends an unfavourable answer, but accompanied with rich presents.

64 Cortes still insists on his demands.

The pusillanimity of the Indian monarch afforded time to the Spaniards to take measures which would have been out of their power had they been vigorously attacked on their first refusal to obey his orders. Cortes used every method of securing the affections of the soldiers; which indeed was very necessary, as many of them began to exclaim against the rashness of his attempt in leading them against the whole force of the Mexican empire. In a short time Teutile arrived with another present from Montezuma, and together with it delivered the ultimate orders of that monarch to depart instantly out of his dominions; and when Cortes, instead of complying with his demands, renewed his request of audience, the Mexican immediately left the camp with strong marks of surprise and resentment. Next morning, none of the natives appeared; all friendly correspondence seemed to be at an end, and hostilities were expected to commence every moment. A sudden consternation ensued among the Spaniards, and a party was formed against him by the adherents of Velasques; who took advantage of the occasion, and deputed one of their number, a principal officer, to remonstrate, as if in name of the whole army, against his rashness, and to urge the necessity of his returning to Cuba. Cortes received the message without any appearance of emotion; and as he well knew the temper and wishes of his soldiery, with much complacency he pretended to comply with the request now made him, and issued orders that the army should be in readiness next day to embark for Cuba. Upon hearing this, the troops, as Cortes had expected, were quite outrageous: they positively refused to comply with these orders, and threatened immediately to choose another general if Cortes continued to insist on their departure.

65 Montezuma peremptorily commands him to leave his dominions.

Our adventurer was highly pleased with the disposition which now appeared among his troops: nevertheless, dissembling his sentiments, he declared, that his orders for embarking had proceeded from a persuasion that it was agreeable to his fellow-soldiers, to whose opinion he had sacrificed his own; but now he acknowledged his error, and was ready to resume his original plan of operation. This speech was highly applauded; and Cortes, without allowing his men time to cool, set about carrying his designs into execution. In order to give a beginning to a colony, he assembled the principal persons in his army, and by their suffrages elected a council and magistrates, in whom the government was to be vested. The persons chosen were most firmly attached to Cortes; and the new settlement had the name of *Villa Rica de la Vera Cruz;* that is, the rich town of the true cross.

66 Villa Rica founded.

Before this court of his own making, Cortes did not hesitate at resigning all his authority, and was immediately re-elected chief-justice of the colony, and captain-general of his army, with an ample commission, in the king's name, to continue in force till the royal pleasure should be farther known. The soldiers eagerly ratified their choice by loud acclamations; and Cortes, now considering himself as no longer accountable to any subject, began to assume a much

67 The government of the new colony vested in Cortes.

much greater degree of dignity, and to exercise more extensive powers than he had done before.

Cortes having thus strengthened himself as well as he could, resolved to advance into the country; and to this he was encouraged by the behaviour of the cacique or petty prince of Zempoalla, a considerable town at no great distance. Here he was received in the most friendly manner imaginable, and had a respect paid towards him almost equivalent to adoration. The cacique informed him of many particulars relating to the character of Montezuma.—He told him that he was a tyrant, haughty, cruel, and suspicious; who treated his own subjects with arrogance, ruined the conquered provinces by his extortions, and often tore their sons and daughters from them by violence; the former to be offered as victims to his gods, the latter to be reserved as concubines for himself and favourites. Cortes, in reply, artfully insinuated, that one great object of the Spaniards in visiting a country so remote from their own was, to redress grievances, and to relieve the oppressed; and having encouraged him to hope for this interposition in due time, continued his march to Quiabislan, the territory of another cacique, and where, by the friendly aid of the Indians, a Spanish colony was soon formed.

68 Character of Montezuma given by the cacique.

During the residence of Cortes in these parts, he so far wrought on the minds of the caciques of Zempoalla and Quiabislan, that they ventured to insult the Mexican power, at the very name of which they had been formerly accustomed to tremble. Some of Montezuma's officers having appeared to levy the usual tribute, and to demand a certain number of human victims, as an expiation of their guilt in presuming to hold intercourse with those strangers whom the emperor had commanded to leave his dominions; instead of obeying his orders, they made them prisoners, treated them with great indignity, and, as their superstition was no less barbarous than Montezuma's, they threatened to sacrifice them to their gods.

Though Cortes had now taken such measures as in a manner ensured his success; yet as he had thrown off all dependence on the governor of Cuba, who was his lawful superior, and apprehended his interest at court, he thought proper, before he set out on his intended expedition, to take the most effectual measures against the impending danger. With this view, he persuaded the magistrates of his colony to address a letter to the king, containing a pompous account of their own services, of the country they had discovered, &c. and of the motives which had induced them to throw off their allegiance to the governor of Cuba, and to settle a colony dependent on the crown alone, in which the supreme power, civil as well as military, had been vested in Cortes; humbly requesting their sovereign to ratify what had been done by his royal authority.

Some soldiers and sailors, secretly disaffected to Cortes, formed a design of seizing one of the brigantines, and making their escape to Cuba, in order to give such intelligence to the governor as might enable him to intercept the vessel which was to carry the treasure and despatches to Spain. This conspiracy was conducted with profound secrecy; but at the moment when every thing was ready for execution, the secret was discovered by one of the associates. The latent spirit of disaffection which Cortes was now too well convinced had not been extinguished amonst his troops, gave him very great uneasiness. The only method which he could think of to prevent such conspiracies for the future was to destroy his fleet, and thus deprive his soldiers of every resource except that of conquest: and with this proposal he persuaded his men to comply. With universal consent therefore the ships were drawn ashore, and, after being stripped of their sails, rigging, iron work, and whatever else might be of use, they were broke in pieces.

69 Cortes burns his fleet.

Cortes having thus rendered it necessary for his troops to follow wherever he chose to lead, began his march to Zempoalla with 500 infantry, 15 horse, and six field pieces. The rest of his troops being less fit for active service, he left them as a garrison in Villa Rica, under the command of Escalante, an officer of merit, and warmly attached to his interest. The cacique of Zempoalla supplied him with provisions; and with 200 of those Indians called *Tamanes*, whose office, in a country where tame animals were unknown, was to carry burdens, and perform all manner of servile labour. He offered likewise a considerable body of troops; but Cortes was satisfied with 400; taking care, however, to choose persons of such note, that they might serve as hostages for the fidelity of their master.

Nothing memorable happened till the Spaniards arrived on the confines of the republic of Tlascala. The inhabitants of that province were warlike, fierce, and revengeful, and had made considerable progress in agriculture and some other arts. They were implacable enemies to Montezuma; and therefore Cortes hoped that it would be an easy matter for him to procure their friendship. With this view, four Zempoallans of high rank were sent ambassadors to Tlascala, dressed with all the badges of that office usual among the Indians. The senate were divided in their opinions with regard to the proposals of Cortes: but at last Magiscatzin, one of the oldest senators, and a person of great authority, mentioned the tradition of their ancestors, and the revelations of their priests; that a race of invincible men, of divine origin, who had power over the elements, should come from the east to subdue their country. He compared the resemblance which the strangers bore to the persons figured in the traditions of Mexico, their dominion over the elements of fire, air, and water; he reminded the senate of their prodigies, omens, and signals, which had lately terrified the Mexicans, and indicated some very important event; and then declared his opinion, that it would be rashness to oppose a force apparently assisted by heaven, and men who had already proved, to the sad experience of those who opposed them, that they were invincible. This orator was opposed by Xicotencal, who endeavoured to prove that the Spaniards were at best but powerful magicians: that they had rendered themselves obnoxious to the gods by pulling down their images and altars (which indeed Cortes had very imprudently done at Zempoalla); and of consequence, that they might easily be overcome, as the gods would not fail to resent such an outrage. He therefore voted for war, and advised the crushing of these invaders at one blow.

70 Sends ambassadors to the republic of Tlascala.

The advice of Xicotencal prevailed; and in consequence of it, the ambassadors were detained; which giving

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giving Cortes the alarm, he drew nearer the city of Tlascala. They suffered him with his army drawn up in good order, to pass a strong wall between two mountains, which might have been very advantageously defended against him. He had not advanced far beyond this pass, however, before a party of Tlascalans with plumes were discovered, which denoted that an army was in the field. These he drove before him by a detachment of six horse, obliged them to join another party, and then reinforcing the advanced detachment, charged the enemy with such vigour that they began to retire. Five thousand Tlascalans then rushed out of their hiding places, just as the infantry came up to assist their slender body of cavalry. The enemy attacked with the utmost fury: but were so much disconcerted by the first discharge of the fire-arms, that they retreated in confusion, furnishing the Spaniards with an opportunity of pursuing them with great slaughter. Cortes, however, supposing that this could not be their whole force, advanced with the utmost caution, in order of battle, to an eminence, from whence he had a view of the main body of the Tlascalan army commanded by Xicotencal, consisting of no fewer than 40,000 men. By these the small army of Cortes was entirely surrounded; which Xicotencal no sooner perceived, than he contracted the circle with incredible diligence, while the Spaniards were almost overwhelmed with showers of arrows, darts, and stones. It is impossible but in this case many of the Spaniards must have perished, had it not been for the insufficiency of the Indian weapons. This circumstance gave the Spaniards a prodigious advantage over them; and therefore the Tlascalans, notwithstanding their valour and superiority in number, could accomplish no more in the present instance, than to kill one horse and slightly wound nine soldiers.

71 The Tlascalans resolve on war.

The Tlascalans being taught by this, and some subsequent encounters, how much they were inferior to the Spaniards, began to conceive them to be really what Magiscatzin had said; a superior order of beings, against whom human power could not prevail. In this extremity they had recourse to their priests, requiring them to reveal the causes of such extraordinary events, and to declare what means they should take to repel such formidable invaders. The priests, after many sacrifices and incantations, delivered their respone, That these strangers were the offspring of the sun, procreated by his animating energy in the regions of the east: that, by day, while cherished with the influence of his parental beams, they were invincible; but by night, when his reviving heat was withdrawn, their vigour declined and faded like herbs in the field, and they dwindled down into mortal men. In consequence of this, the Tlascalans acted in contradiction to one of their most established maxims in war, and ventured to attack the enemy in the night time, hoping to destroy them when enfeebled and surprised. But the Spanish centinels having observed some extraordinary movements among the Tlascalans, gave the alarm. Immediately the troops were under arms, and sallying out, defeated their antagonists with great slaughter, without allowing them to approach the camp. By this disaster the Tlascalans were heartily disposed to peace; but they were at a loss to form an adequate idea of the enemies they had to deal with. They could not ascertain the nature of these surprising beings, or whether they were really of a benevolent or malignant disposition. There were circumstances in their behaviour which seemed to favour each opinion. On the one hand, as the Spaniards constantly dismissed the prisoners whom they took, not only without injury, but often with presents of European toys, and renewed their offers of peace after every victory; this lenity amazed people accustomed to the exterminating system of war known in America, and who sacrificed and devoured without mercy all the captives taken in battle; and disposed them to entertain sentiments favourable to their humanity. But, on the other hand, as Cortes had seized 50 of their countrymen who brought provisions to their camp, and cut off their heads; this bloody spectacle, added to the terror occasioned by the fire-arms and horses, filled them with dreadful ideas of their ferocity. Accordingly they addressed them in the following manner: "If (said they) you are divinities of a cruel and savage nature, we present to you five slaves, that you may drink their blood and eat their flesh. If you are mild deities, accept an offering of incense and variegated plumes. If you are men, here is meat, bread and fruit, to nourish you." After this address, the peace was soon concluded, to the great satisfaction of both parties. The Tlascalans yielded themselves as vassals to the crown of Castile, and engaged to assist Cortes in all his operations; while he took the republic under his protection, and promised to defend their persons and possessions from injury and violence.

72 But are defeated and sue for peace.

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73 Which is granted.

Cortes left no method untried to gain the favour and confidence of the Tlascalans; which, however, he had almost entirely lost, by his untimely zeal in destroying their idols as he had done those of Zempoalla. But he was deterred from this rash action by his chaplain Father Bartholomew de Olmedo; and left the Tlascalans in the undisturbed exercise of their superstition, requiring only that they should desist from their horrid practice of offering human victims. As soon as his troops were fit for service, he resolved to continue his march towards Mexico, notwithstanding the remonstrances of the Tlascalans, who looked upon his destruction as unavoidable if he put himself into the power of such a faithless prince as Montezuma. But the emperor, probably intimidated with the fame of his exploits, had resolved to admit his visit; and informed Cortes that he had given orders for his friendly reception at Cholula, the next place of any consequence on the road to Mexico. Cortes was received with much seeming cordiality; but 6000 Tlascalan troops who accompanied him were obliged to remain without the town, as the Cholulans refused to admit their ancient enemies within their precincts. Yet two of these, by disguising themselves, got into the city, and acquainted Cortes that they observed the women and children belonging to the principal citizens retiring every night in a great hurry, and that six children had been sacrificed in the great temple; a sign that some warlike enterprise was at hand. At the same time Donna Marina, the interpreter, received information from an Indian woman of distinction, whose confidence she had gained, that the destruction of the Spaniards was concerted; that a body of Mexican troops lay concealed near the town; that some of the streets were barricaded, in others deep pits or trenches were dug,

74 Cortes continues his march for Mexico.

75 Treachery of Montezuma and the Cholulans.

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dug, and slightly covered over, as traps into which the horse might fall; that stones and missile weapons were collected on the tops of the temples, with which to overwhelm the infantry; that the fatal hour was already at hand, and their ruin unavoidable. Cortes, alarmed at this news, secretly arrested three of the chief priests, from whom he extorted a confession that confirmed the intelligence he had already received. As not a moment was to be lost, he instantly resolved to prevent his enemies, and to inflict on them such dreadful vengeance as might strike Montezuma and his subjects with terror. On a signal given, the troops rushed out, and fell upon the multitude, destitute of leaders, and so much astonished, that the weapons dropped from their hands, and they stood motionless, and incapable of defence. While the Spaniards attacked them in front, the Tlascalans did the same in the rear; the streets were filled with slaughter; the temples, which afforded a retreat to the priests and some leading men, were set on fire, and they perished in the flames. At length the carnage ceased, after the slaughter of 6000 Cholulans, without the loss of a single Spaniard. Cortes then released the magistrates; and reproaching them bitterly for their intended treachery, declared, that as justice was now appeased, he forgave the offence; but required them to recal the inhabitants who had fled, and re-establish order in the town.

76 Severe punishment of the Cholulans.

77 Disaffection of Montezuma's subjects.

From Cholula, Cortes advanced directly towards Mexico; and throughout the whole of his journey was entertained with accounts of the oppressions and cruelty of Montezuma. This gave him the greatest hope of accomplishing his design; as he now perceived that the empire was entirely divided, and no sort of unanimity prevailed among them. No enemy appeared to check his progress. Montezuma was quite irresolute; and Cortes was almost at the gates of the capital before the emperor had determined whether to receive him as a friend or oppose him as an enemy. But as no sign of open hostility appeared, the Spaniards, without regarding the fluctuations of Montezuma's sentiments, continued their march to Mexico, with great circumspection and the strictest discipline, though without seeming to suspect the prince whom they were about to visit.

78 Meeting of Cortes and Montezuma.

When they drew near the city, about 1000 persons who appeared to be of distinction, came forth to meet them, adorned with plumes, and clad in mantles of fine cotton. Each of these, in his order, passed by Cortes, and saluted him according to the mode deemed most respectful and submissive in their country. They announced the approach of Montezuma himself, and soon after his harbingers came in sight. There appeared first 200 persons in an uniform dress, with large plumes of feathers, alike in fashion, marching two and two, in deep silence, barefooted, with their eyes fixed on the ground. These were followed by a company of higher rank, in their most showy apparel: in the midst of whom was Montezuma, in a chair or litter richly ornamented with gold and feathers of various colours. Four of his principal favourites carried him on their shoulders, others supported a canopy of curious workmanship over his head. Before him marched three officers with rods of gold in their hands, which they lifted up on high at certain intervals; and at that signal all the people bowed their heads, and hid their faces, as unworthy to look on so great a monarch. When he drew near, Cortes dismounting, advanced towards him with officious haste, and in a respectful posture. At the same time Montezuma alighted from his chair, and leaning on the arms of two of his near relations, approached with a slow and stately pace, his attendants covering the streets with cotton cloths, that he might not touch the ground. Cortes accosted him with profound reverence, after the European fashion. He returned the salutation, according to the mode of his country, by touching the earth with his hand, and then kissing it. This ceremony appeared such amazing condescension in a proud monarch, who scarcely deigned to consider the rest of mankind as of the same species with himself, that all his subjects firmly believed those persons, before whom he humbled himself in this manner, to be something more than human. Accordingly, as they marched through the crowd, the Spaniards frequently, and with much satisfaction, heard themselves denominated *teules*, or *divinities*. Nothing material passed in this first interview. Montezuma conducted Cortes to the quarters which he had prepared for his reception; and immediately took leave of him with a politeness not unworthy of a court more refined: "You are now (says he), with your brothers, in your own house; refresh yourselves after your fatigue, and be happy until I return." The place allotted to the Spaniards for their lodging was a house built by the father of Montezuma. It was surrounded by a stone wall, with towers at proper distances, which served for defence as well as for ornament; and its apartments and courts were so large as to accommodate both the Spaniards and their Indian allies. The first care of Cortes was to take precautions for his security, by planting the artillery so as to command the different avenues which led to it, by appointing a large division of his troops to be always on guard, and by posting centinels at proper stations, with injunctions to observe the same vigilant discipline as if they were within sight of an enemy's camp.

In the evening Montezuma returned to visit his guests with the same pomp as in their first interview; and brought presents of such value, not only to Cortes and to his officers, but even to the private men, as proved the liberality of the monarch to be suitable to the opulence of his kindom. A long conference ensued, in which Cortes learned what was the opinion of Montezuma with respect to the Spaniards. It was an established tradition, he told him, among the Mexicans, that their ancestors came originally from a remote region, and conquered the provinces now subject to his dominion; that after they were settled there, the great captain who conducted this colony returned to his own country, promising, that at some future period his descendants should visit them, assume the government, and reform their constitutions and laws: that, from what he had heard and seen of Cortes and his followers, he was convinced that they were the very persons whose appearance their prophecies taught them to expect; that accordingly he had received them, not as strangers, but as relations of the same blood and parentage, and desired that they might consider themselves as masters in his dominions; for both himself and his subjects should be ready to comply with their will, and even to prevent their wishes. Cortes made a reply

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ply in his usual style with respect to the dignity and power of his sovereign, and his intention in sending him into that country; artfully endeavouring so to frame his discourse, that it might coincide as much as possible with the idea which Montezuma had formed concerning the origin of the Spaniards. Next morning, Cortes and some of his principal attendants were admitted to a public audience of the emperor. The three subsequent days were employed in viewing the city; the appearance of which, so far superior in the order of its buildings and the number of its inhabitants to any place the Spaniards had beheld in America, and yet so little resembling the structure of an European city, filled them with surprise and admiration.

79 Description of the city of Mexico.

Mexico is situated in a large plain, environed by mountains of such height, that though within the torrid zone, the temperature of its climate is mild and healthful. All the moisture which descends from the high grounds is collected in several lakes, the two largest of which, of about 90 miles in circuit, communicate with each other. The waters of the one are fresh, those of the other brackish. On the banks of the latter, and on some small islands adjoining to them, the capital of Montezuma's empire was built. The access to the city was by artificial causeways or streets, formed of stones and earth, about 30 feet in breadth. As the waters of the lake, during the rainy season, overflowed the flat country, these causeways were of considerable length. That of Tacuba on the west a mile and a half; that of Tezcuco on the north-west three miles; that of Cuoyacan towards the south six miles. On the east there was no causeway, and the city could be approached only by canoes. In each of these causeways were openings at proper intervals, through which the waters flowed; and over these beams of timber were laid, which being covered with earth, the causeway or street had everywhere an uniform appearance. As the approaches to the city were singular, its construction was remarkable. Not only the temples of their gods, but the houses belonging to the monarch, and to persons of distinction, were of such dimensions, that in comparison with any other buildings which had been discovered in America, they might be termed *magnificent*. The habitations of the common people were mean, resembling the huts of other Indians. But they were all placed in a regular manner, on the banks of the canals which passed through the city, in some of its districts, or on the sides of the streets which intersected it in other quarters. In several places were large openings or squares, one of which, allotted for the great market, is said to have been so spacious that 40,000 or 50,000 persons carried on traffic there. In this city, the pride of the New World, and the noblest monument of the industry and art of man, while unacquainted with the use of iron, the Spaniards, who are most moderate in their computations, reckon that there were at least 60,000 inhabitants.

80 Uneasiness of the Spaniards.

But how much soever the novelty of those objects might amuse or astonish the Spaniards, they felt the utmost solicitude with respect to their own situation. From a concurrence of circumstances, no less unexpected than favourable to their progress, they had been allowed to penetrate into the heart of a powerful kingdom, and were now lodged in its capital, without having once met with open opposition from its monarch. The Tlascalans, however, had earnestly dissuaded them from placing such confidence in Montezuma as to enter a city of such a peculiar situation as Mexico, where that prince would have them at mercy, shut up as it were in a snare, from which it was impossible to escape. They assured them that the Mexican priests had, in the name of the gods, counselled their sovereign to admit the strangers into the capital, that he might cut them off there at one blow with perfect security. The Spaniards now perceived, too plainly, that the apprehensions of their allies were not destitute of foundation; that, by breaking the bridges placed at certain intervals on the causeways, or by destroying part of the causeways themselves, their retreat would be rendered impracticable, and they must remain cooped up in the centre of a hostile city, surrounded by multitudes sufficient to overwhelm them, and without a possibility of receiving aid from their allies.

81 Some hostilities between the Spaniards and Mexicans.

Before he set out from Cholula, Cortes had received advice from Villa Rica, that Qualpopoca, one of the Mexican generals on the frontiers, having assembled an army in order to attack some of the people whom the Spaniards had encouraged to throw off the Mexican yoke, Escalante had marched out with part of the garrison to support his allies; that an engagement had ensued, in which, though the Spaniards were victorious, Escalante, with seven of his men, had been mortally wounded, his horse killed, and one Spaniard had been surrounded by the enemy and taken alive; that the head of this unfortunate captive, after being carried in triumph to different cities, in order to convince the people that their invaders were not immortal, had been sent to Mexico. Cortes, though alarmed with this intelligence, as an indication of Montezuma's hostile intentions, had continued his march. But as soon as he entered Mexico he became sensible, that, from an excess of confidence in the superior valour and discipline of his troops, as well as from the disadvantage of having nothing to guide him in an unknown country but the defective intelligence which he received from people with whom his mode of communication was very imperfect, he had pushed forward into a situation, where it was difficult to continue, and from which it was dangerous to retire. Disgrace, and perhaps ruin, was the certain consequence of attempting the latter. The success of his enterprise depended upon supporting the high opinion which the people of New Spain had formed with respect to the irresistible power of his arms. Upon the first symptom of timidity on his part, their veneration would cease, and Montezuma, whom fear alone restrained at present, would let loose upon him the whole force of his empire. At the same time, he knew that the countenance of his own sovereign was to be obtained only by a series of victories; and that nothing but the merit of extraordinary success could screen his conduct from the censure of irregularity. From all these considerations, it was necessary to maintain his station, and to extricate himself out of the difficulties in which one bold step had involved him, by venturing upon another still bolder. The situation was trying, but his mind was equal to it; and after revolving the matter with deep attention, he fixed upon a plan no less extraordinary than daring. He determined to seize Montezuma in his palace, and carry him a prisoner to the

82 Cortes resolves to seize Montezuma in his palace.

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the Spanish quarters. From the superstitious veneration of the Mexicans for the person of their monarch, as well as their implicit submission to his will, he hoped, by having Montezuma in his power, to acquire the supreme direction of their affairs; or at least, with such a sacred pledge in his hands, he made no doubt of being secure from any effort of their violence.

This he immediately proposed to his officers. The timid startled at a measure so audacious, and raised objections. The more intelligent and resolute, conscious that it was the only resource in which there appeared any prospect of safety, warmly approved of it, and brought over their companions so cordially to the same opinion, that it was agreed instantly to make the attempt. At his usual hour of visiting Montezuma, Cortes went to the palace, accompanied by Alvarado, Sandoval, Lugo, Velasquez de Leon, and Davila, five of his principal officers, and as many trusty soldiers. Thirty chosen men followed, not in regular order, but sauntering at some distance, as if they had no object but curiosity; small parties were posted at proper intervals, in all the streets leading from the Spanish quarters to the court; and the remainder of his troops, with the Tlascalan allies, were under arms, ready to sally out on the first alarm. Cortes and his attendants were admitted without suspicion; the Mexicans retiring, as usual out of respect. He addressed the monarch in a tone very different from that which he had employed in former conferences; reproaching him bitterly as the author of the violent assault made upon the Spaniards by one of his officers, and demanding public reparation for the loss which he had sustained by the death of some of his companions, as well as for the insult offered to the great prince whose servants they were. Montezuma, confounded at this unexpected accusation, and changing colour either from the consciousness of guilt, or from feeling the indignity with which he was treated, asserted his own innocence with great earnestness; aud, as a proof of it, gave orders instantly to bring Qualpopoca and his accomplices prisoners to Mexico. Cortes replied, with seeming complaisance, that a declaration so respectable left no doubt remaining in his own mind; but that something more was requisite to satisfy his followers, who would never be convinced that Montezuma did not harbour hostile intentions against them, unless, as an evidence of his confidence and attachment, he removed from his own palace and took up his residence in the Spanish quarters, where he should be served and honoured as became a great monarch. The first mention of so strange a proposal bereaved Montezuma of speech, and almost of motion. At length he haughtily answered, "That persons of his rank were not accustomed voluntarily to give up themselves as prisoners; and were he mean enough to do so, his subjects would not permit such an affront to be offered to their sovereign." Cortes, unwilling to employ force, endeavoured alternately to soothe and intimidate him. The altercation became warm: and having continued above three hours, Velasquez de Leon, an impetuous and gallant young man, exclaimed with impatience, "Why waste more time in vain? Let us either seize him instantly, or stab him to the heart." The threatening voice and fierce gestures with which these words were uttered, struck Montezuma. The Spaniards, he was sensible, had now proceeded so far, as left him no hope that they would recede. His own danger was imminent, the necessity unavoidable. He saw both; and abandoning himself to his fate, complied with their request.

83
The emperor carried to the Spanish quarters.

His officers were called. He communicated to them his resolution. Though astonished and afflicted, they presumed not to question the will of their master, but carried him in silent pomp, all bathed in tears, to the Spanish quarters.

They at first pretended to treat Montezuma with great respect; but soon took care to let him know that he was entirely in their power. Cortes wished that the shedding the blood of a Spaniard should appear the most heinous crime that could be committed; and therefore not only took a most exemplary vengeance on those who had been concerned in the affair of Villa Rica, but even put the emperor himself in chains till the execution of the Mexican general was over. By these, and other insults, he at last gained entirely the ascendant over this unhappy monarch; and he took care to improve his opportunity to the utmost. He sent his emissaries into different parts of the kingdom, accompanied with Mexicans of distinction, who might serve both to guide and to protect them. They visited most of the provinces, viewed their soil and productions, surveyed with particular care the districts which yielded gold or silver, pitched upon several places as proper for future colonies, and endeavoured to prepare the minds of the people for submitting to the Spanish yoke: and while they were thus employed, Cortes, in the name and by the authority of Montezuma, degraded some of the principal officers in the empire, whose abilities or independent spirit excited his jealousy; and substituted in their place persons who he imagined would be more obsequious. One thing, however, was still wanting to complete his security. He wished to have such a command of the lake as might ensure a retreat, if, either from levity or disgust, the Mexicans should take arms against him, and break down the bridges or causeways, in order to enclose him in the city. In order to obtain this without giving disgust to the emperor or his court, Cortes artfully inflamed the curiosity of the Indians with accounts of the Spanish shipping, and those floating palaces that moved with such velocity on the water, without the assistance of oars; and when he found that the monarch himself was extremely desirous of seeing such a novelty, he gave him to understand, that nothing was wanting to his gratification besides a few necessaries from Vera Cruz, for that he had workmen in his army capable of building such vessels. The bait took with Montezuma; and he gave immediate orders that all his people should assist Cortes in whatever he should direct concerning the shipping. By this means, in a few days, two brigantines were got ready, full rigged and equipped; and Montezuma was invited on board, to make the first trial of their sailing, of which he could form no idea. Accordingly he embarked for this purpose, and gave orders for a great hunting upon the water, in order that all his people might be diverted with the novelty presented by the Spaniards. On the day appointed, the royal equipage was ready early in the morning; and the lake was covered with a multitude of boats and canoes loaded with people. The Mexicans had augmented the

84
Cortes rules the empire.

85
By a pretence, he obtains leave to build two brigantines on the lake.

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the number of their rowers on board the royal barges, with an intention to disgrace the Spanish vessels, which they regarded as clumsy, unwieldy, and heavy. But they were soon undeceived; a fresh gale started up, the brigantines hoisted sail, to the utter astonishment of all the spectators, and soon left all the canoes behind; while the monarch exulted in the victory of the Spaniards, without once considering that now he had effectually rivetted his own chains.

86 Montezuma owns himself a vassal to the king of Spain.

Cortes having obtained this important point, resolved to put the condescension of the emperor to a trial still more severe. He urged Montezuma to acknowledge himself a vassal to the crown of Castile; to hold his crown of him as superior, and to subject his dominions to the payment of an annual tribute. With this requisition, humiliating as it was, Montezuma complied. He called together the chief men of his empire, and, in a solemn harangue, reminded them of the traditions and prophecies which led them to expect the arrival of a people sprung from the same stock with themselves, in order to take possession of the supreme power; he declared his belief that the Spaniards were this promised race; and that therefore he recognised the right of their monarch to govern the Mexican empire, would lay his crown at his feet, and obey him as a tributary. While uttering these words, Montezuma discovered how deeply he was affected in making such a sacrifice. Tears and groans frequently interrupted his discourse. The first mention of such a resolution struck the assembly dumb with astonishment. This was followed by a sullen murmur of sorrow mingled with indignation; which indicated some violent eruption of rage to be near at hand. This Cortes foresaw, and seasonably interposed to prevent it, by declaring that his master had no intention to deprive Montezuma of the royal dignity, or to make any innovation upon the constitution and laws of the Mexican empire. This assurance, added to their dread of the Spanish arms, and the authority of their monarch's example, extorted the consent of the assembly; and the act of submission and homage was executed with all the formalities which the Spaniards pleased to prescribe.

Montezuma, at the request of Cortes, accompanied this profession of fealty and homage with a magnificent present to his new sovereign; and, after his example, his subjects brought in very liberal contributions. The Spaniards then collected all the treasure which had been either voluntarily bestowed upon them at different times by Montezuma, or had been extorted from his people under various pretences; and having melted the gold and silver, the value of these amounted to 600,000 pesos. The soldiers were impatient to have it divided; and Cortes complied with their desire. A fifth of the whole was set apart as the tax due to the king. Another fifth was allowed to Cortes as commander. The sums advanced by the governor of Cuba, who had originally fitted out the expedition, were then deducted. The remainder was then divided among the army, including the garrison of Vera Cruz, in proportion to their different ranks; and after so many deductions, the share of a private man did not exceed 100 pesos. This sum fell so far below their sanguine expectations, that it required all the address, and no small exertions of the liberality of Cortes, to prevent an open mutiny. However, he at last restored tranquillity; but had no sooner escaped this danger, than he involved himself by his imprudent zeal for religion, in one much worse. Montezuma, though often importuned, had obstinately refused to change his religion, or abolish the superstitious rites which had been for such a long time practised throughout his dominions. This at last transported the Spaniards with such rage, that, in a sally of zeal, he led out his soldiers in order to throw down the idols in the great temple by force. But the priests taking arms in defence of their altars, and the people crowding with great ardour to support them, Cortes's prudence overruled his zeal, and induced him to desist from his rash attempt, after dislodging the idols from one of the shrines, and placing in their stead an image of the Virgin Mary.

87 The Spaniards divide their treasure.

88 Cortes attempts to destroy the Mexican idols.

89 Which produces a general disaffection.

From this moment the Mexicans began to meditate the expulsion or the destruction of the Spaniards. The priests and leading men held frequent meetings with Montezuma for this purpose. But as any violent attempt might have proved fatal to the captive monarch, it was thought proper first to try more gentle means. Having called Cortes into his presence, he observed, that now, as all the purposes of his embassy were fully accomplished, the gods had declared their will, and the people signified their desire, that he and his followers should instantly depart out of the empire. With this he required them to comply, or unavoidable destruction would fall suddenly on their heads. This unexpected requisition, as well as the manner in which it was delivered, alarmed Cortes. However, he supposed that more might be gained by a feigned compliance than by open resistance; and therefore replied with great composure, that he had already begun to prepare for his return; but as he had destroyed the vessels in which he arrived, some time was requisite for building other ships. This appeared reasonable; and a number of Mexicans were sent to Vera Cruz to cut down timber, and some Spanish carpenters were appointed to superintend the work.

90 The Spaniards are commanded to depart.

91 An armament sent from Cuba against Cortes.

Cortes flattered himself, that, during this interval, he might either find means to avert the threatened danger, or receive such reinforcements as would enable him to defend himself. Nine months had now elapsed since Portocarrero and Montejo had sailed with his despatches to Spain; and he daily expected a return, with a confirmation of his authority from the king, without which all that he had done served only to mark him out as an object of punishment. While he remained in great anxiety on this account, news were brought that some ships had appeared on the coast. These were imagined by Cortes to be a reinforcement sent him from Spain: but his joy was of short continuance, for a courier very soon arrived from Vera Cruz, with certain information that the armament was fitted out by Velasquez, the governor of Cuba; and instead of bringing succours, threatened them with immediate destruction.

Velasquez had been excited to this hostile measure chiefly through the indiscretion, or rather treachery, of the messengers of Cortes; who, contrary to his express injunctions, had landed on the island of Cuba, and given intelligence of all that had passed: and Velasquez, transported with rage at hearing of the proceedings of Cortes, had now sent against him this armament; consisting of 18 ships, which carried 80 horsemen,

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men, 800 infantry, of which 80 were musketeers, and 120 cross bowmen, commanded by a brave officer named *Pamphilo de Narvaez;* whose instructions were, to seize Cortes and his principal officers, to send them prisoners to him, and then to complete the discovery and conquest of the country in his name. This proved a most afflicting piece of news to Cortes.

92
Which is defeated by that general.

Having now no resource but in war, he left 150 men under the command of Pedro de Alvarado, an officer of great bravery, and much respected by the Mexicans, to guard the capital and the captive emperor; while he himself marched with the remainder, to meet his formidable opponent, who had taken possession of Zempoalla. Even after being reinforced by Sandoval his governor of Vera Cruz, the force of Cortes did not exceed 250 men. He hoped for success chiefly from the rapidity of his motions and the possibility of surprising his enemies; and as he chiefly dreaded their cavalry, he armed his soldiers with long spears, accustoming them to that deep and compact arrangement which the use of this formidable weapon enabled them to assume. As he advanced, however, he repeated his proposals of accommodation; but these being constantly rejected, and a price set upon his head, he at last attacked Narvaez in the night-time, entirely defeated and took him prisoner, obliging all his troops to own allegiance to himself.

Nothing could be more seasonable than this victory, by which Cortes found his army very considerably increased; for most of the soldiers of Narvaez chose rather to follow Cortes than to return to Cuba, whither the conqueror had offered to send them if they chose. His affairs at Mexico, in the mean time, were in the utmost danger of being totally ruined; and had this decisive victory been delayed but a few days longer, he must have come too late to save his companions. A short time after the defeat of Narvaez, a courier arrived from Mexico with the disagreeable intelligence that the Mexicans had taken arms; and having seized and destroyed the two brigantines which he had built in order to secure the command of the lake, had attacked the Spaniards in their quarters, killed some, and wounded many more, burnt their magazine of provisions, and, in short, carried on hostilities with such fury, that though Alvarado and his men defended themselves with undaunted resolution, they must either be cut off by famine, or sink under the multitude of their enemies. This revolt was excited by motives which rendered it still more alarming. On the departure of Cortes for Zempoalla, the Mexicans flattered themselves, that the long-expected opportunity of restoring their sovereign to liberty, and driving out the Spaniards, was arrived; and consultations were accordingly held for bringing about both these events. The Spaniards in Mexico, conscious of their own weakness, suspected and dreaded these machinations; but Alvarado, who had neither the prudence nor the address of Cortes, took the worst method imaginable to overcome them. Instead of attempting to soothe or cajole the Mexicans, he waited the return of one of their solemn festivals, when the principal persons in the empire were dancing, according to custom, in the court of the great temple; he seized all the avenues which led to it; and, allured partly by the rich ornaments which they wore in honour of their gods, and partly by the facility of cutting off at once the authors of that conspiracy which he dreaded, he fell upon them, unarmed and unsuspicious of danger, and massacred a great number; none escaping but such as made their way over the battlements of the temple. An action so cruel and treacherous filled not only the city, but the whole empire, with indignation and rage; and the Mexicans immediately proceeded in the manner above mentioned.

93
Dangerous situation of the Spaniards left in Mexico.

Cortes advanced with the utmost celerity to the relief of his distressed companions: but as he passed along, had the mortification to find that the Spaniards were generally held in abhorrence. The principal inhabitants had deserted the towns through which he passed; no person of note appeared to meet him with the usual respect; nor were provisions brought to his camp as usual. Notwithstanding these signs of aversion and horror, however, the Mexicans were so ignorant of the military art, that they again permitted him to enter the capital without opposition; though it was in their power to have easily prevented him, by breaking down the bridges and causeways which led to it.

94
Cortes allowed to return to Mexico;

Cortes was received by his companions with the utmost joy; and this extraordinary success so far intoxicated the general himself, that he not only neglected to visit Montezuma, but expressed himself very contemptuously concerning him. These expressions being reported among the Mexicans, they all at once flew to arms, and made such a violent and sudden attack, that all the valour and skill of Cortes were scarce sufficient to repel them. This produced great uneasiness among the soldiers of Narvaez, who had imagined there was nothing to do but to gather the spoils of a conquered country. Discontent and murmurings, however, were now of no avail; they were enclosed in a hostile city, and, without some extraordinary exertions, were inevitably undone. Cortes, therefore, made a desperate sally; but, after exerting his utmost efforts for a whole day, was obliged to retire with the loss of 12 killed, and upwards of 60 wounded. Another sally was attempted with the like bad success, and in it Cortes himself was wounded in the hand.

95
but is furiously attacked by the natives.

The Spanish general was now thoroughly convinced of his error; and therefore betook himself to the only resource which was left; namely, to try what effect the interposition of Montezuma would have to soothe or overawe his subjects. When the Mexicans approached the next morning to renew the assault, that unfortunate prince, at the mercy of the Spaniards, and reduced to the sad necessity of becoming the instrument of his own disgrace, and of the slavery of his people, advanced to the battlements in his royal robes, and with all the pomp in which he used to appear on solemn occasions. At the sight of their sovereign, whom they had been long accustomed to reverence almost as a god, the Mexicans instantly forebore their hostilities, and many prostrated themselves on the ground: but when he addressed them in favour of the Spaniards, and made use of all the arguments he could think of to mitigate their rage, they testified their resentment with loud murmurings; and at length broke

96
Montezuma killed.

forth

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forth with such fury, that before the soldiers, appointed to guard Montezuma, had time to cover him with their shields, he was wounded with two arrows, and a blow on his temple with a stone struck him to the ground. On seeing him fall, the Mexicans instantly fled with the utmost precipitation: but the unhappy monarch, now convinced that he was become an object of contempt even to his own subjects, obstinately refused all nourishment; and thus in a short time ended his days.

97 A terrible engagement between the Spaniards and Mexicans.

On the death of Montezuma, Cortes having lost all hope of bringing the Mexicans to any terms of peace, prepared for retreat. But his antagonists, having taken possession of a high tower in the great temple, which overlooked the Spanish quarters, and placing there a garrison of their principal warriors, the Spaniards were so much exposed to their missile weapons, that none could stir without danger of being killed or wounded. From this post, therefore, it was necessary to dislodge them at any rate; and Juan de Escobar, with a large detachment of chosen soldiers, was ordered to make the attack. But Escobar, though a valiant officer, and though he exerted his utmost efforts, was thrice repulsed. Cortes, however, sensible that not only his reputation, but the safety of his army, depended on the success of this assault, caused a buckler to be tied to his arm, as he could not manage it with his wounded hand, and rushed with his drawn sword amongst the thickest of the combatants. Encouraged by the presence of their general, the Spaniards returned to the charge with such vigour, that they gradually forced their way up the steps, and drove the Mexicans to the platform at the top of the tower. There a dreadful carnage began; when two young Mexicans of high rank, observing Cortes, as he animated his soldiers, resolved to sacrifice their own lives in order to cut off the author of so many calamities which desolated their country. They approached him in a suppliant posture, as if they intended to lay down their arms; and seizing him in a moment, hurried him towards the battlements, over which they threw themselves headlong, in hopes of dragging him along with them. But Cortes, by his strength and agility, disengaged himself from their grasp; so that the two Mexicans perished alone.

As soon as the Spaniards became masters of the tower, they set fire to it, and without further molestation continued the preparations for their retreat. This became the more necessary, as their enemies, astonished at this last effort of their valour, had now entirely changed their system of hostility; and, instead of incessant attacks, endeavoured, by barricading the streets, and breaking down the causeways, to cut off the communication of the Spaniards with the continent, and thus to starve an enemy whom they could not subdue. The first point to be determined, was whether they should march out openly in the face of day, when they could discern every danger, or whether they should endeavour to retire secretly in the night. The latter was preferred, partly from hopes that the superstition of the Mexicans would prevent them from attacking them in the night, and partly from their own superstition in giving credit to the predictions of a private soldier, who pretended to astrology, and assured them of success if they retreated in this manner. Towards midnight, therefore, they began their march, in three divisions. Sandoval led the van; Pedro Alvarado and Velasquez de Leon had the conduct of the rear; and Cortes commanded in the centre, where he placed the prisoners, among whom were a son and two daughters of Montezuma, together with several Mexicans of distinction, the artillery, baggage, and a portable bridge of timber intended to be laid over the breaches in the causeway. They marched in profound silence along the causeway which led to Tacuba, because it was shorter than any of the rest, and, lying more remote from the road towards Tlascala and the sea coast, had been left most entire by the Mexicans.

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98 Cortes retreats with great loss.

They reached the first breach in the causeway without molestation, hoping that their retreat was undiscovered. But the Mexicans had not only watched all their motions, but made preparations for a most formidable attack. While the Spaniards were intent upon placing their bridges in the breach, and occupied in conducting their horses and artillery along it, they were suddenly alarmed with the sound of warlike instruments, and found themselves assaulted on all sides by an innumerable multitude of enemies. Unfortunately the wooden bridge was wedged so fast in the mud by the weight of the artillery, that it was impossible to remove it. Dismayed at this accident, the Spaniards advanced with precipitation to the second breach. The Mexicans hemmed them in on every side; and though they defended themselves with their usual courage, yet, crowded as they were in a narrow causeway, their discipline and military skill were of little avail; nor did the obscurity of the night allow them to derive much advantage from their fire-arms or the superiority of their other weapons. At last the Spaniards, overborne with the numbers of their enemies, began to give way, and in a moment the confusion was universal. Cortes, with about 100 foot soldiers, and a few horse, forced his way over the two remaining breaches in the causeway, the bodies of the dead serving to fill up the chasms, and reached the main land. Having formed them as soon as they arrived, he returned with such as were yet capable of service, to assist his friends in their retreat. He met with part of his soldiers who had forced their way through the enemy, but found many more overwhelmed by the multitude of their aggressors, or perishing in the lake; and heard the grievous lamentations of others whom the Mexicans were carrying off in triumph to be sacrificed to the god of war.

In this fatal retreat more than one half of Cortes's army perished, together with many officers of distinction. All the artillery, ammunition, and baggage, were lost; the greater part of the horses and above 2000 Tlascalans were killed, and only a very small part of their treasure saved. The first care of the Spanish general was to find some shelter for his wearied troops; for, as the Mexicans infested them on every side, and the people of Tacuba began to take arms, he could not continue in his present station. At last he discovered a temple seated on an eminence, in which he found not only the shelter he wanted, but some provisions; and though the enemy did not intermit their attacks throughout the day, they were without much difficulty prevented from making any impression. For six

six days after, they continued their march through a barren, ill cultivated, and thinly peopled country, where they were often obliged to feed on berries, roots, and the stalks of green maize; at the same time they were harassed without intermission by large parties of Mexicans, who attacked them on all sides. On the sixth day they reach Otumba, not far from the road between Mexico and Tlascala. Early next morning they began to advance towards it, flying parties of the enemy still hanging on their rear; and amidst the insults with which they accompanied their hostilities, Donna Marina remarked, that they often exclaimed with exultation, "Go on, robbers; go to the place where you shall quickly meet the vengeance due to your crimes." The meaning of this threat the Spaniards did not comprehend, until they reached the summit of an eminence before them. There a spacious valley opened to their view, covered with a vast army as far as the eye could reach. The Mexicans, while with one body of their troops they harassed the Spaniards in their retreat, had assembled their principal force on the other side of the lake; and marching along the road which led directly to Tlascala, posted it in the plain of Otumba, through

99 The battle of Otumba.

which they knew Cortes must pass. At the sight of this incredible multitude, which they could survey at once from the rising ground, the Spaniards were astonished, and even the boldest began to despair. But Cortes, without allowing their fears time to operate, after warning them briefly that no alternative remained but to conquer or die, led them instantly to the charge. The Mexicans waited their approach with unusual fortitude: yet such was the superiority of the Spanish discipline and arms, that the impression of this small body was irresistible; and whichever way its force was directed, it penetrated and dispersed the most numerous battalions. But while these gave way in one quarter, new combatants advanced from another; and the Spaniards, though successful in every attack, were ready to sink under these repeated efforts, without seeing any end to their toil, or any hope of victory. At that time Cortes observed the great standard of the empire, which was carried before the Mexican general, advancing; and fortunately recollecting to have heard, that on the fate of it depended the event of every battle, he assembled a few of his bravest officers, whose horses were still capable of service, and placing himself at their head, pushed towards the standard with such impetuosity that he bore down every thing before him. A chosen body of nobles, who guarded the standard, made some resistance, but were soon broken. Cortes, with a stroke of his lance, wounded the Mexican general, and threw him to the ground. One of his followers alighting, put an end to his life, and laid hold of the imperial standard. The moment that their leader fell, and the standard, towards which all directed their eyes, disappeared, an universal panic struck the Mexicans; and, as if the bond which held them together had been dissolved, every ensign was lowered, each

100 Mexicans defeated.

soldier threw away his weapons, and fled with precipitation to the mountains. The Spaniards, unable to pursue them far, returned to collect the spoils of the field; and these were so valuable as to be some compensation for the wealth which they had lost in Mexico; for in the enemy's army were most of their principal warriors dressed out in their richest ornaments, as if they had been marching to assured victory.

The day after this important action (being July 8. 1520), the Spaniards entered the Tlascalan territories, where they were received with the most cordial friendship. Cortes endeavoured to avail himself of this disposition as much as possible; for which purpose he distributed among them the rich spoils taken at Otumba with such a liberal hand, that he made himself sure of obtaining from the republic whatever he should desire. He drew a small supply of ammunition, and two or three field-pieces, from his stores at Vera Cruz. He despatched an officer of confidence with four ships of Narvaez's fleet to Hispaniola and Jamaica, to engage adventurers, and to purchase horses, gunpowder, and other military stores. And as he knew that it would be in vain to attempt the reduction of Mexico, unless he could secure the command of the lake, he gave orders to prepare, in the mountains of Tlascala, materials for building 12 brigantines, so that they might be carried thither in pieces, ready to be put together, and launched when he stood in need of their service. But, in the mean time, his soldiers, alarmed at the thoughts of being exposed to such calamities a second time, presented a remonstrance to their general; in which they represented the imprudence of attacking a powerful empire with his shattered forces, and formally required him to return back to Cuba. All the eloquence of Cortes could now only prevail with them to delay their departure for some time, when he promised to dismiss such as should desire it. However, this was only a pretence; for Cortes, in fact, had the conquest of Mexico as much at heart as ever. Without giving his soldiers an opportunity of caballing, therefore, he daily employed them against the people of the neighbouring provinces, who had cut off some detachments of Spaniards during his misfortunes at Mexico; and by which, as he was constantly attended with success, his men soon resumed their wonted sense of superiority.

101 Cortes receives an unexpected reinforcement.

But all the efforts of Cortes could have been of little avail, had he not unexpectedly obtained a reinforcement of Spanish soldiers. These belonged to an armament fitted out by Francisco de Garay, governor of Jamaica, who had long aimed at dividing with Cortes the glory and gain of annexing the empire of Mexico to the crown of Castile. They had, however, unadvisedly made their attempt on the northern provinces, where the country was poor and the inhabitants fierce and warlike; so that, after a succession of disasters, they were now obliged to venture into Vera Cruz, and cast themselves upon the mercy of their countrymen; and here they also were soon persuaded to throw off their allegiance to their master, and to enlist with Cortes. About the same time a ship arrived from Spain, freighted by some private adventurers, with military stores; and the cargo was eagerly purchased by Cortes, while the crew, following the example of the rest, joined him at Tlascala.

From these various quarters, the army of Cortes was augmented with 180 men and 20 horses; by which means he was enabled to dismiss such of the soldiers of Narvaez as were most troublesome and discontented; after the departure of whom he still mustered 550 infantry, of whom 80 were armed with muskets or cross-

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cross bows, 40 horsemen, and nine pieces of artillery. At the head of these, with 10,000 Tlascalans and other friendly Indians, he began his march towards Mexico, on the 28th of December, six months after his fatal retreat from that city.

102 He sets out again for Mexico.

As soon as Cortes entered the enemy's territories, he discovered various preparations to obstruct his progress. But his troops forced their way with little difficulty; and took possession of Tezcuco, the second city of the empire, situated on the banks of the lake, about 20 miles from Mexico. Here he determined to establish his head quarters, as the most proper station for launching his brigantines, as well as for making his approaches to the capital. In order to render his residence there more secure, he deposed the cacique or chief, who was at the head of that community, under pretence of some defect in his title, and substituted in his place a person whom a faction of the nobles pointed out as the right heir of that dignity. Attached to him by this benefit, the new cacique and his adherents served the Spaniards with inviolable fidelity.

As the construction of the brigantines advanced slowly under the unskilful hands of soldiers and Indians, whom Cortes was obliged to employ in assisting three or four carpenters who happened fortunately to be in his service, and as he had not yet received the reinforcement which he expected from Hispaniola, he was not in a condition to turn his arms directly against the capital. To have attacked a city so populous, so well prepared for defence, and in a situation of such peculiar strength, must have exposed his troops to inevitable destruction. Three months elapsed before the materials for constructing the brigantines were finished, and before he heard any thing with respect to the success of his negociation in Hispaniola. This, however, was not a season of inaction to Cortes. He attacked successively several of the towns situated around the lake; and though all the Mexican power was exerted to obstruct his operations, he either compelled them to submit to the Spanish crown, or reduced them to ruins. Other towns he endeavoured to conciliate by more gentle means; and though he could not hold any intercourse with the inhabitants but by the intervention of interpreters, yet, under all the disadvantages of that tedious and imperfect mode of communication, he had acquired such a thorough knowledge of the state of the country, as well as of the dispositions of the people, that he conducted his negociations and intrigues with astonishing dexterity and success. Most of the cities adjacent to Mexico were originally the capitals of small independent states; and some of them having been but lately annexed to the Mexican empire, still retained the remembrance of their ancient liberty, and bore with impatience the rigorous yoke of their new masters. Cortes having early observed symptoms of their disaffection, availed himself of this knowledge to gain their confidence and friendship. By offering with confidence to deliver them from the odious dominion of the Mexicans, and by liberal promises of more indulgent treatment if they would unite with him against their oppressors, he prevailed on the people of several considerable districts, not only to acknowledge the king of Castile as their sovereign, but to supply the Spanish camp with provisions, and to strengthen his army with auxiliary troops. Guatimozin, on the first appearance of defection among his subjects, exerted himself with vigour to prevent or to punish their revolt; but, in spite of his efforts, the spirit continued to spread. The Spaniards gradually acquired new allies; and with deep concern he beheld Cortes arming against his empire those very hands which ought to have been active in his defence, and ready to advance against the capital at the head of a numerous body of his own subjects.

103 Cortes makes great progress.

While, by these various methods, Cortes was gradually circumscribing the Mexican power within such narrow limits that his prospect of overturning it seemed neither to be uncertain nor remote, all his schemes were well nigh defeated by a conspiracy against his own person, and which was discovered only a short time before it was to have been executed. Though many were concerned, Cortes did not think proper to punish any more than the principal ringleader, whom he caused immediately to be hanged; and then, without allowing them leisure to ruminate on what had happened, and as the most effectual means of preventing the return of a mutinous spirit, he determined to call forth his troops immediately to action. Fortunately a proper occasion for this occurred, without his seeming to court it. He received intelligence, that the materials for building the brigantines were at length completely finished, and waited only for a body of Spaniards to conduct them to Tezcuco. The command of this convoy, consisting of 200 foot soldiers, 15 horsemen, and two field-pieces, he gave to Sandoval, who by the vigilance, activity, and courage, which he manifested on every occasion, was growing daily in his confidence, and in the estimation of his fellow-soldiers. The Tlascalans furnished 8000 *Tamenes*, an inferior order of men destined for servile tasks, to carry the materials on their shoulders, and appointed 15,000 warriors to accompany and defend them. Sandoval made the disposition for their progress with great propriety, placing the Tamenes in the centre, one body of warriors in the front, another in the rear, with considerable parties to cover the flanks. To each of these he joined some Spaniards, not only to assist them in danger, but to accustom them to regularity and subordination. Parties of Mexicans frequently appeared hovering around them on the high grounds: but perceiving no prospect of success in attacking an enemy continually on his guard, and prepared to receive them, they did not venture to molest him; and Sandoval had the glory of conducting safely to Tezcuco a convoy on which all the future operations of his countrymen depended.

104 Mexico besieged.

Cortes determined to attack the city from three different quarters; from Tezcuco on the east side of the lake, from Tacuba on the west, and from Cuayocan towards the south. Those towns were situated on the principal causeways which led to the capital, and intended for their defence. He appointed Sandoval to command in the first, Pedro de Alvarado in the second, and Christoval de Olid in the third; allotting to each a numerous body of Indian auxiliaries, together with an equal division of Spaniards, who, by the junction of the troops from Hispaniola, amounted now to 86 horsemen, and 818 foot foot soldiers; of whom 118 were armed with muskets or cross-bows. Their train of artillery consisted of three battering cannon, and 15 field-pieces.

pieces. He reserved for himself, as the station of greatest importance and danger, the conduct of the brigantines, each armed with one of his small cannon, and manned with 25 Spaniards.

As Alvarado and Olid proceeded towards the posts assigned them, they broke down the aqueducts which the ingenuity of the Mexicans had erected for conveying water into the capital, and, by the distress to which this reduced the inhabitants, gave a beginning to the calamities which they were destined to suffer. Alvarado and Olid found the towns, of which they were ordered to take possession, deserted by their inhabitants, who had fled for safety to the capital, where Guatimozin had collected the chief force of his empire, as there alone he could hope to make a successful stand against the formidable enemies who were approaching to assault him.

105 The Spaniards defeat the Mexicans, and become masters of the lake.

The first effort of the Mexicans was to destroy the fleet of brigantines, the fatal effects of whose operations they foresaw and dreaded. Though the brigantines, after all the labour and merit of Cortes in forming them, were of inconsiderable bulk, rudely constructed, and manned chiefly with landmen, hardly possessed of skill enough to conduct them, they must have been objects of terror to a people unacquainted with any navigation but that of their lake, and possessed of no vessel larger than a canoe. Necessity, however, urged Guatimozin to hazard the attack; and hoping to supply by numbers what he wanted in force, he assembled such a multitude of canoes as covered the face of the lake. They rowed on boldly to the charge, while the brigantines, retarded by a dead calm, could scarcely advance to meet them. But as the enemy drew near, a breeze suddenly sprung up; in a moment the sails were spread, and the brigantines with irresistible impetuosity broke their feeble opponents, overset many canoes, and dissipated the whole armament with such slaughter, as convinced the Mexicans, that the progress of the Europeans in knowledge and arts rendered their superiority greater on this new element than they had hitherto found it by land.

From that time Cortes remained master of the lake; and the brigantines not only preserved a communication between the Spaniards in their different stations, though at a considerable distance from each other; but were employed to cover the causeways on each side, and keep off the canoes, when they attempted to annoy the troops as they advanced towards the city. He formed the brigantines in three divisions, allotting one to each station, with orders to second the operations of the officer who commanded there. From all the three stations he pushed on the attack against the city with equal vigour; but in a manner so very different from that by which sieges are conducted in regular war, as might appear no less improper than singular to persons unacquainted with his situation. Each morning his troops assaulted the barricades which the enemy had erected on the causeways, forced their way over the trenches which they had dug, and through the canals where the bridges were broken down, and endeavoured to penetrate into the heart of the city, in hopes of obtaining some decisive advantage, which might force the enemy to surrender, and terminate the war at once; but when the obstinate valour of the Mexicans rendered the efforts of the day ineffectual, the Spaniards retired in the evening to their former quarters. Thus their toil and danger were, in some measure, continually renewed, the Mexicans repairing in the night what the Spaniards had destroyed through the day, and recovering the posts from which they had driven them. But necessity prescribed this slow and untoward mode of operation. The number of his troops was so small, that Cortes durst not, with a handful of men, attempt to make a lodgement in a city where he might be surrounded and annoyed by such a multitude of enemies. The remembrance of what he had already suffered by the ill-judged confidence with which he had ventured into such a dangerous situation, was still fresh in his mind. The Spaniards, exhausted with fatigue, were unable to guard the various posts which they daily gained; and though their camp was filled with Indian auxiliaries, they durst not devolve this charge upon them, because they were so little accustomed to discipline, that no confidence could be placed in their vigilance. Besides this, Cortes was extremely solicitous to preserve the city as much as possible from being destroyed, both as he destined it to be the capital of his conquests, and wished that it might remain as a monument of his glory. From all these considerations, he adhered obstinately, for a month after the siege was opened, to the system which he had adopted. The Mexicans, in their own defence, displayed valour which was hardly inferior to that with which the Spaniards attacked them. On land, on water, by night and by day, one furious conflict succeeded to another. Several Spaniards were killed, more wounded, and all were ready to sink under the toils of unintermitting service, which were rendered more intolerable by the injuries of the season, the periodical rains being now set in with their usual violence.

Astonished and disconcerted with the length and difficulties of the siege, Cortes determined to make one great effort to get possession of the city before he relinquished the plan which he had hitherto followed, and had recourse to any other mode of attack. With this view he sent instructions to Alvarado and Sandoval to advance with their divisions to a general assault, and took the command in person of that posted on the causeway of Cuyocan. Animated by his presence, and the expectation of some decisive event, the Spaniards pushed forward with irresistible impetuosity. They broke through one barricade after another, forced their way over the ditches and canals, and having entered the city, gained ground incessantly, in spite of the multitude and ferocity of their opponents. Cortes, though delighted with the rapidity of his progress, did not forget that he might still find it necessary to retreat; and in order to secure it, appointed Julian de Alderete, a captain of chief note in the troops which he had received from Hispaniola, to fill up the canals and gaps in the causeway as the main body advanced. That officer deeming it inglorious to be thus employed, while his companions were in the heat of action and the career of victory, neglected the important charge committed to him, and hurried on inconsiderately to mingle with the combatants. The Mexicans, whose military attention and skill were daily improving, no sooner observed this, than they carried an account of it to their monarch.

Guatimozin instantly discerned the consequences of the

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106 Cortes repulsed in an attack.

The approach of night, though it delivered the dejected Spaniards from the attacks of the enemy, ushered in, what was hardly less grievous, the noise of their barbarous triumph, and of the horrid festival with which they celebrated their victory. Every quarter of the city was illuminated; the great temple shone with such peculiar splendour, that the Spaniards could plainly see the people in motion, and the priests busy in hastening the preparations for the death of the prisoners. Through the gloom they fancied that they discerned their companions by the whiteness of their skins, as they were stripped naked and compelled to dance before the image of the god to whom they were to be offered. They heard the shrieks of those who were sacrificed, and thought they could distinguish each unhappy victim by the well known sound of his voice. Imagination added to what they really saw or heard, and augmented its horror. The most unfeeling melted into tears of compassion, and the stoutest heart trembled at the dreadful spectacle which they beheld.

Cortes, who, besides all that he felt in common with his soldiers, was oppressed with the additional load of anxious reflections natural to a general on such an unexpected calamity, could not like them relieve his mind by giving vent to its anguish. He was obliged to assume an air of tranquillity in order to revive the spirits and hopes of his followers. The juncture, indeed, required an extraordinary exertion of fortitude. The Mexicans, elated with their victory, sallied out next morning to attack him in his quarters. But they did not rely on the efforts of their own arms alone: they sent the heads of the Spaniards whom they had sacrificed to the leading men in the adjacent provinces, and assured them that the god of war, appeased by the blood of their invaders, which had been shed so plentifully on his altars, had declared with an audible voice, that in eight days time those hated enemies should be finally destroyed, and peace and prosperity re-established in the empire. History.

107 The Mexicans renew the attack with great fury.

A prediction, uttered with such confidence, and in terms so void of ambiguity, gained universal credit among a people prone to superstition. The zeal of the provinces which had already declared against the Spaniards augmented, and several which had hitherto remained inactive took arms with enthusiastic ardour to execute the decrees of the gods. The Indian auxiliaries who had joined Cortes, accustomed to venerate the same deities with the Mexicans, and to receive the responses of their priests with the same implicit faith, abandoned the Spaniards as a race of men devoted to certain destruction. Even the fidelity of the Tlascalans was shaken, and the Spanish troops were left almost alone in their stations. Cortes, finding that he attempted in vain to dispel the superstitious fears of his confederates by argument, took advantage, from the imprudence of those who had framed the prophecy in fixing its accomplishment so near at hand, to give them a striking demonstration of its falsity. He suspended all military operations during the period marked out by the oracle. Under cover of the brigantines, which kept the enemy at a distance, his troops lay in safety, and the fatal term expired without any disaster.

His allies, ashamed of their own credulity, returned to their station. Other tribes, judging that the gods, who had now deceived the Mexicans, had decreed finally to withdraw their protection from them, joined his standard; and such was the levity of a simple people, moved by every slight impression, that, in a short time after such a general defection of his confederates, Cortes saw himself, if we may believe his own account, at the head of 150,000 Indians. Even with such a numerous army, he found it necessary to adopt a new and more wary system of operation. Instead of renewing his attempts to become master of the city at once, by such bold but dangerous efforts of valour as he had already tried, he made his advances gradually, and with every possible precaution against exposing his men to any calamity similar to that which they still bewailed. As the Spaniards pushed forward, the Indians regularly repaired the causeways behind them. As soon as they got possession of any part of the town, the houses were instantly levelled with the ground. Day by day, the Mexicans, forced to retire as their enemies gained ground, were hemmed in within more narrow limits. Guatimozin, though unable to stop the career of the enemy, continued to defend his capital with obstinate resolution, and disputed every inch of ground. But the Spaniards, having not only varied their mode of attack, but, by order of Cortes, having changed the weapons with

108 Cortes adopts a more cautious method of proceeding.

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with which they fought, were again armed with the long Chinantlan spears, which they had employed with such success against Narvaez: and, by the firm array in which this enabled them to range themselves, they repelled, with little danger, the loose assault of the Mexicans; incredible numbers of whom fell in the conflicts, which they renewed every day. While war wasted without, famine began to consume them within the city. The Spanish brigantines, having the entire command of the lake, rendered it impossible to receive any supply of provisions by water. The vast number of his Indian auxiliaries enabled Cortes to shut up the avenues to the city by land. The stores which Guatimozin had laid up were exhausted by the multitudes which crowded into the capital to defend their sovereign and the temples of their gods. Not only the people, but persons of the highest rank, felt the utmost distresses of want. What they suffered brought on infectious and mortal distempers, the last calamity that visits besieged cities, and which filled up the measure of their woes.

109 Guatimozin refuses to submit on any terms.

But, under the pressure of so many and such various evils, the spirit of Guatimozin remained firm and unsubdued. He rejected with scorn every overture of peace from Cortes; and, disdaining the idea of submitting to the oppressors of his country, determined not to survive its ruin. The Spaniards continued their progress. At length all the three divisions penetrated into the great square in the centre of the city, and made a secure lodgment there. Three-fourths of the city were now reduced, and laid in ruins. The remaining quarter was so closely pressed, that it could not long withstand assailants who attacked it from their new station with superior advantage, and more assured expectation of success. The Mexican nobles, solicitous to save the life of a monarch whom they revered, prevailed on Guatimozin to retire from a place where resistance was now vain, that he might rouse the more distant provinces of the empire to arms, and maintain there a more successful struggle with the public enemy. In order to facilitate the execution of this measure, they endeavoured to amuse Cortes with overtures of submission, that, while his attention was employed in adjusting the articles of pacification, Guatimozin might escape unperceived. But they made this attempt upon a leader of greater sagacity and discernment than to be deceived by their arts. Cortes suspecting their intention, and aware of what moment it was to defeat it, appointed Sandoval, the officer on whose vigilance he could most perfectly rely, to take the command of the brigantines, with strict injunctions to watch every motion of the enemy. Sandoval, attentive to the charge, observing some large canoes crowded with people rowing along the lake with extraordinary rapidity, instantly gave the signal to chase. Gracia Holguin, who commanded the fleetest brigantine, soon overtook them, and was preparing to fire on the foremost canoe, which seemed to carry some person whom all the rest followed and obeyed. At once the rowers dropt their oars, and all on board, throwing down their arms, conjured him with cries and tears to forbear, as the emperor was there. Holguin eagerly seized his prize; and Guatimozin, with a dignified composure, gave himself up into his hands, requesting only that no insult might be offered to the empress or his children. When conducted to Cortes, he appeared neither with the sullen fierceness of a barbarian, nor with the dejection of a supplicant. "I have done," said he, addressing himself to the Spanish general, "what became a monarch. I have defended my people to the last extremity. Nothing now remains but to die. Take this dagger," laying his hand on one which Cortes wore, "plant it in my breast, and put an end to a life which can no longer be of use."

110 He is taken prisoner.

111 Mexico submits.

As soon as the fate of their sovereign was known, the resistance of the Mexicans ceased; and Cortes took possession of that small part of the capital which yet remained undestroyed. Thus terminated the siege of Mexico, the most memorable event in the conquest of America. It continued 75 days, hardly one of which passed without some extraordinary effort of one party in the attack, or of the other in the defence of a city, on the fate of which both knew that the fortune of the empire depended. As the struggle here was more obstinate, it was likewise more equal, than any between the inhabitants of the Old and New Worlds. The great abilities of Guatimozin, the number of his troops, the peculiar situation of his capital, so far counterbalanced the superiority of the Spaniards in arms and discipline, that they must have relinquished the enterprise, if they had trusted for success to themselves alone. But Mexico was overturned by the jealousy of neighbours who dreaded its power, and by the revolt of subjects impatient to shake off its yoke. By their effectual aid, Cortes was enabled to accomplish what, without such support, he would hardly have ventured to attempt. How much soever this account of the reduction of Mexico may detract, on the one hand, from the marvellous relations of some Spanish writers, by ascribing that to simple and obvious causes which they attribute to the romantic valour of their countrymen, it adds, on the other, to the merit and abilities of Cortes, who, under every disadvantage, acquired such an ascendant over unknown nations, as to render them instruments towards carrying his scheme into execution.

The exultation of the Spaniards, on accomplishing this arduous enterprise, was at first excessive. But this was quickly damped by the cruel disappointment of those sanguine hopes which had animated them amidst so many hardships and dangers. Instead of the inexhaustible weath which they expected from becoming masters of Montezuma's treasures, and the ornaments of so many temples, their rapaciousness could collect only an inconsiderable booty amidst ruins and desolation (A). Guatimozin, aware of his impending fate, had ordered what remained of the riches amassed by his ancestors to be thrown into the lake. The Indian auxiliaries, while the Spaniards were engaged in conflict

(A) The gold and silver, according to Cortes, amounted only to 120,000 pesos, (Relat. 280, A.) a sum far inferior to that which the Spaniards had formerly divided in Mexico.

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flict with the enemy, had carried off the most valuable part of the spoil. The sum to be divided among the conquerors was so small, that many of them disdained to accept of the pittance which fell to their share, and all murmured and exclaimed: some against Cortes and his confidants, whom they suspected of having secretly appropriated to their own use a large portion of the riches which should have been brought into the common stock; others against Guatimozin, whom they accused of obstinacy, in refusing to discover the place where he had hidden his treasure.

Arguments, entreaties, and promises, were employed in order to soothe them; but with so little effect, that Cortes, from solicitude to check this growing spirit of discontent, gave way to a deed which stained the glory of all his great actions. Without regarding the former dignity of Guatimozin, or feeling any reverence for those virtues which he had displayed, he subjected the unhappy monarch, together with his chief favourite, to torture, in order to force from them a discovery of the royal treasures, which it was supposed they had concealed. Guatimozin bore whatever the refined cruelty of his tormentors could inflict, with the invincible fortitude of an American warrior. His fellow-sufferer, overcome by the violence of the anguish, turned a dejected eye towards his master, which seemed to implore his permission to reveal all that he knew. But the high-spirited prince, darting on him a look of authority mingled with scorn, checked his weakness, by asking, "Am I now reposing on a bed of flowers?" Overawed by the reproach, he persevered in his dutiful silence, and expired. Cortes, ashamed of a scene so horrid, rescued the royal victim from the hands of his torturers, and prolonged a life reserved for new indignities and sufferings.

112 Guatimozin tortured.

113 The Spaniards become masters of the whole Mexican empire.

The fate of the capital, as both parties had foreseen, decided that of the empire. The provinces submitted one after another to the conquerors. Small detachments of Spaniards marching through them without interruption, penetrated, in different quarters, to the great Southern ocean, which, according to the ideas of Columbus, they imagined would open a short as well as easy passage to the East Indies, and secure to the crown of Castile all the envied wealth of those fertile regions; and the active mind of Cortes began already to form schemes for attempting this important discovery. In his after-schemes, however, he was disappointed; but Mexico hath ever since remained in the hands of the Spaniards.

Till Humboldt's work appeared, the internal situation of Mexico was very imperfectly known. This celebrated traveller, who spent a considerable time in visiting the most remarkable objects, and had access to the best sources of information, has furnished us with a very interesting account of the colony.

One of the most remarkable peculiarities of New Spain is the great elevation of the soil. Three fifths of the viceroyalty consist of table land, elevated from 6000 to 8000 feet above the sea. It presents a continuous and hardly broken plain between 18° and 40° of north latitude. The slight ridges that interrupt it seldom rise more than 600 or 800 feet above the valleys they separate. Some of the mountains, however, are of colossal magnitude. The tops of four only are covered with perpetual snow, the highest of which has an altitude of 17,700 feet. The table land gradually declines towards the north. The more elevated plains are arid, destitute of trees, and covered with a saline efflorescence. But the greater part of it is extremely fertile, and the whole exceedingly healthy. It enjoys a dry and light atmosphere, and a mild and temperate climate. The medium temperature of winter is from 55° to 57° of Fahrenheit's thermometer, and in the greatest heat of summer it never rises above 75°. On the coast, however, the air is moist, hot, and unwholesome, and the medium temperature of the whole year is about 78° or 79°. The settlers divide the cultivated part into three zones. 1. The *tierras calientes*, or warm grounds, which never rising 1000 feet above the sea, have a heat of about 80°, and yield abundantly sugar, indigo, cotton, plantains, or bananas. 2. The *tierras templadas*, or temperate grounds, which lying on the declivity of the great ridge, at an altitude from 4000 to 5000 feet, enjoy a mild vernal temperature of 68° or 70°, that seldom varies 10° through the whole year. 3. The *tierras frias*, or cold grounds, having an elevation of 8000 feet, and comprehending the high plains or table land, of which the temperature is generally under 63°, and never exceeds 75°.

Rivers, Lakes, &c.

The great chain of mountains called the *Andes* is continued through the isthmus of Panama and through all Mexico, until they are lost in the unknown mountains of the north. The most considerable of that chain is known in Mexico by the name of *Sierra Madre*.

Mexico, like Old Spain, suffers from the want of water and navigable rivers. The Rio Bravo del Norte, and the Rio Colorado are the most considerable, the former having a course of 512 leagues, and the latter of 250. Those rivers, however, are situated in the most uncultivated part of the country. In the southern part of Mexico there are only small rivers, the Alvarado, Guasacualco, Mortezuma, and Zacatula; but the Santiago which flows westward, and falls into the Pacific ocean in latitude $21\frac{1}{2}$°, is a large river.

There are likewise in this country several lakes of very considerable magnitude; but those of Nicaragua, Chapalla, and Pazquaro, which are of the greatest extent, did not belong to the ancient Mexican empire. The most remarkable were those in the vale of Mexico, upon which the capital of the empire was founded. Of these, the fresh water one, called the *lake of Chalco*, extended in length from east to west 12 miles, as far as the city of Xochimilco; from thence, taking a northerly direction, it incorporated itself by means of a canal with the lake of Tezeuco; but its breadth did not exceed six miles. The other, named the *lake of Tezcuco*, extended 15, or rather 17 miles from east to west, and something more from south to north; but its extent is now much less, by reason of the Spaniards having diverted the course of many of the streams which run into it. This lake is salt, which Clavigero supposes to arise from the nature of the soil which forms its bed.

Besides these, there are a number of smaller lakes, some of which are very delightful. There is a vast variety of mineral waters, of the nitrous, sulphureous, and aluminous kinds, some of them so hot that meat may be boiled in them. At Tetuhuacan is a kind of petrifying water, as well as in several other parts of

Vegetable Productions.

of the empire. One of them forms a kind of smooth white stones, not displeasing to the taste; the scrapings of which taken in broth are celebrated as a diaphoretic, probably without any good reason. The dose for a person not difficult to be sweated is one dram of the scrapings. Many of the rivers of Mexico afford surprising and beautiful cascades; particularly the river Guadalaxara, at a place called *Tempizque*, 15 miles to the southward of that city. Along a deep river called *Atoyaque* is a natural bridge, consisting of a vast mound of earth, along which carriages pass conveniently. Clavigero supposes it to have been the fragment of a mountain thrown down by an earthquake, and then penetrated by the river.

The agriculture of Mexico, with all other branches of industry, have been much improved within the last 30 or 40 years; and so far from the mines operating against it, the cultivation of the soil is generally carried on with the greatest spirit in the mining districts. The plantain or banana tree, which is cultivated over an extent of country containing a million and a half of inhabitants, yields so great a produce, that an *arpent* of ground covered with it will maintain 50 persons, though if sown with wheat it would not support two. The fruit is farinaceous, and contains much saccharine matter. The tree does not thrive where the medium temperature is below 75° F. The cassava root, which grows also in the warm region, at a height from 2000 to 2700 feet, affords a flour, called manioc, which has the inestimable advantage, that when dried and toasted it is secure from the depredations of worms and other insects. But maize is the chief food of the inhabitants. It is cultivated from the coast to the height of 9000 feet above the sea. On very fertile lands, and in good years, it yields 800 for 1; but the average return for the intratropical part of the country is not more than 150 for 1, and in New California 70 or 80. The crop is very uncertain, and as it is seldom equally good in every part of the country, the transport of maize comes to be the principal branch of internal commerce. A general failure is followed by scarcity, or even famine. Its price varies from $2\frac{1}{2}$ to 25 livres the fanega (equal to $1\frac{1}{2}$ English bushels). The annual produce of New Spain in maize is estimated at 17 millions of fanegas. The Mexican wheat is of excellent quality, and the medium return is from 22 to 25 for 1. Much wheat is exported to Cuba. Barley and rye thrive well; oats are very little cultivated. The potato is raised abundantly in the high and cold parts of the country. Rice is but little attended to, though well adapted for the marshy lands on the coast. The cerealia are not cultivated in the intratropical part of Mexico, at a lower elevation than about 2700 feet above the sea, and in very small quantity at a less height than 4000. Neither wheat nor rye come to maturity at a greater height than 12000 feet.

The sugar cane has been successfully introduced into some of the interior provinces of the continent. Sugar plantations are spreading rapidly in the plain of Mexico, and supply not only the home consumption, but afford an export of half a million of arobas (equal to about 25 lbs. avoirdupois each). The sugar cane is not cultivated by slaves.

The Spanish government has always discouraged the cultivation of the vine, the olive, the mulberry-tree, and the plants producing hemp and flax. When Humboldt was in the country, an order came from Madrid to grub up all the vines in the northern parts of the kingdom, where they had been cultivated with so much success as to give alarm to the merchants of Cadiz, by the diminished consumption of wine from the mother country. There is but one olive plantation in the country, which belongs to the archbishop of Mexico. Since 1764, when the royal monopoly was established, no tobacco can be planted, except in particular districts, and none can be sold except to the king's officers. Parties of soldiers are employed to go about the country in search of tobacco fields; and where they find one on forbidden ground, they impose a fine on the owner, and direct the plantation to be destroyed. This monopoly produces a revenue of more than 20 millions of livres annually.

From maize the Indians obtain several kinds of beer or cyder by fermentation. A spirituous liquor named *pulque* is also procured from this plant. But the intoxicating liquor most in use, and which is also called *pulque*, is made from the *agave Americana*. A vigorous plant will afford four gallons of sap per day during four or five months; and this when fermented three or four days forms *pulque*. It tastes like cyder, but has an offensive smell of meat in a state of putrefaction. The ardent spirit from it is strictly prohibited by law, lest it should interfere with the sale of Spanish brandy; but great quantities of it are made clandestinely.

Cotton, indigo, coffee, and cacao, are not cultivated to a great extent in New Spain. But the whole of the vanilla consumed in Europe comes from the provinces of Oaxaca and Vera Cruz, amounting to 900,000 pods, the value of which, at Vera Cruz, is about 30,000 or 40,000 piastres or dollars. The province of Oaxaca also furnishes 32,000 arobas of cochineal, valued at 2,400,000 dollars.

The whole annual produce of the agriculture of New Spain is valued by Humboldt at 29 millions of dollars; and as this amount is founded on accurate returns of the amount of the tithes, and was revised and corrected by well informed persons, it may be considered as a near approximation to the truth.

The wages of labour in New Spain are $2\frac{1}{2}$ reals de plata a-day on the coast, and 2 reals de plata, or $\frac{1}{4}$ dollar, on the table land. The average price of maize on the table land is estimated by Humboldt at 5 livres the fanega; and consequently a labourer on the table land, earns about $1\frac{3}{4}$ pecks of Indian corn a-day. Wheat is dearer in the city of Mexico than in Paris, chiefly in consequence of the cost of transportation.

The tree producing liquid amber, the liquid storax of the Mexicans, is of a large size, the leaves similar to those of the maple, indented, white in one part and dark in the other, disposed in threes; the fruit is thorny and round, but polygonous, with the surface and the angles yellow; the bark of the tree partly green and partly tawney. By incisions in the trunk they extract that valuable substance named *liquid amber*, and the oil of the same name, which is still more valuable. Liquid amber is likewise obtained from a decoction of the branches, but it is inferior to that obtained from the trunk.

The name *copalli* in Mexico is generic, and common

mon to all the resins; but especially signifies those made use of for incense. There are ten species of these trees yielding resins of this kind; the principal of which is that from which the COPAL is got, so well known in medicine and varnishes. A great quantity of this was made use of by the ancient Mexicans, and is still used for similar purposes by the Spaniards. The *tecopalli* or *tepecopalli* is a resin similar to the incense of Arabia; which distils from a tree of moderate size that grows in the mountains, having a fruit like an acorn, and containing the nut enveloped in a mucilage, within which there is a small kernel useful in medicine.

The *mitzquitl*, or mezquite, is a species of true acacia, and the gum distilled from it is said to be the true gum arabic. It is a thorny shrub, with branches irregularly disposed, the leaves small, thin, and pinnated; the flowers being like those of the birch-tree. Of the elastic gum, which is found in plenty in Mexico, the natives were in use to make foot-balls, which, though heavy, have a better spring than those filled with air. With this they varnish their hats, cloaks, boots, and great coats, in a manner similar to what is done in Europe with wax; and by which means they are rendered all water proof.

114 Mexican animals.

The quadrupeds found in Mexico at the arrival of the Spaniards, were lions, tygers, wild cats, bears, wolves, foxes, the common stags, white stags, bucks, wild goats, badgers, polecats, weasels, martins, squirrels, polatucas, rabbits, hares, otters, and rats. All these animals are supposed to be common to both continents. The white stag, whether it be the same species of the other or not, is undoubtedly common to both, and was known to the Greeks and Romans. The Mexicans call it the *king of the stags*. M. Buffon imagines the white colour of this creature to be the effect of captivity; but Clavigero says, that it is found wild, and of the same white colour, on the mountains of New Spain. In many other points, he also controverts the opinions of this celebrated naturalist, who will not allow the lion, tyger, or rabbit, to be natives of America.

Clavigero enumerates the quadrupeds common to New Spain with the rest of the continent of America. Among these he will not allow a place to the Peruvian sheep, the *huanaco*, and sloth; all of which are peculiar to South America. Hernandez indeed makes mention of the Peruvian sheep, and gives a drawing of it; but this was only on account of a few individuals brought thence from Peru, which the Mexicans called by that name, in the same manner as he describes several animals of the Philippine isles; not that they had ever been bred in Mexico, or found in any country of North America, unless it was some individual carried there, as they are carried as a curiosity from Europe. The animals which he allows to be common to both countries, are, the Mexican hog, the moufete, the opossum, the armadillo, the *techichi*, a small animal resembling a dog; which being perfectly dumb, gave occasion to a report that the Mexican dogs could not bark. The flesh of this animal was eaten by them, and was esteemed agreeable and nourishing food. After the conquest of Mexico, the Spaniards having neither large cattle nor sheep, provided their markets with this quadruped; by which means, the species soon came to be extinct, though it had been very numerous. The land-squirrel is very numerous in the kingdom of Michuacan, has great elegance of form, and is extremely graceful in its movements; but it cannot be tamed, and bites most furiously every person who approaches it.

Besides these, there are sea lions, ratoons, and that voracious animal named the *tapir*. Oviedo informs us, that he has seen it at one bite tear off two or three hand-breadths of skin from a hound, and at another a whole leg and thigh. The flesh is eatable, and its skin is valued on account of its being sufficiently strong to resist musket-balls. There are likewise great numbers of monkeys of many different kinds; some of which have heads resembling those of dogs. Some of them are strong and fierce, equalling a man in stature when they stand upright.

Among the animals peculiar to Mexico, is one named *coyoto*, which appears to have been inaccurately described by natural historians; some making it one species and some another. It is about the size of a mastiff, but more slender. The eyes are yellow and sparkling, ears small, pointed, and erect; the snout blackish, strong limbs, and the feet armed with large crooked nails. The tail is thick and hairy, the skin a mixture of black, brown, and white; and the voice is compounded of the howl of the wolf and the bark of the dog. It pursues the deer, and will sometimes even attack men. Its usual pace is a trot, but so quick that a horse at the gallop can scarcely overtake it. The *tlalcojotl* or *tlalcoyoto* is about the size of a middling dog, and the largest animal that lives under the earth. Its head has some resemblance to that of a cat; but in colour and length of hair it resembles the lion.—It has a long thick tail, and feeds upon poultry and small animals, which it catches in the night-time. The *tepeizuintli*, or mountain-dog, though it is but of the size of a small dog, is so bold that it attacks deer, and sometimes kills them. Its hair and tail are long, the body black, but the head, neck, and breast, white. M. Buffon reckons this animal the same with the glutton, but Clavigero denies it. Another animal, larger than the two foregoing, is called the *xoloitzcuintli*. Some of these are no less than four feet in length. It has a face like the dog, but tusks like the wolf, with erect ears, the neck gross, and the tail long.—It is entirely destitute of hair, excepting only the snout, where there are some thick crooked bristles. The whole body is covered with a smooth, soft ash-coloured skin, spotted partly with black and tawney. This species of animals, as well as the two former, are almost totally extinct. A Lyncean academician named *Giovanni Febri*, has endeavoured to prove that the xoloitzcuintli is the same with the wolf of Mexico; but this is denied by Clavigero.

A curious animal of the mole kind is called *tozan* or *tuza*. It is about the size of a European mole, but very different otherwise. The body is about seven or eight inches long, and well made; the snout like that of a mouse, the ears small and round, with the tail short. The mouth is armed with very strong teeth, and its paws are furnished with strong crooked nails, with which it digs its habitation in the earth. It is extremely destructive to the corn fields by the quantity of grain it steals, and to the highways by the number

Animals. ber of holes it makes in them; for when, on account of the dimness of its sight, it cannot find its first hole, it makes another, and so on. It digs the earth with its claws and two canine teeth, which it has in the upper jaw.

115 Mexican Birds. The birds are so numerous, and of such various appearances and qualities, that Mexico has been called the country of birds, as Africa is of quadrupeds. Hernandez describes above 200 peculiar to the country. He allows to the eagles and hawks of Mexico a superiority over those of Europe; and the falcons of this country were formerly esteemed so excellent, that, by the desire of Philip II. a hundred of them were sent every year over to Spain. The largest, the most beautiful, and the most valuable kind of eagles, is called by the Mexicans *itzquauhtli*, and will pursue not only the larger kinds of birds, but quadrupeds, and even men.

The ravens of Mexico, do not, like those of other countries, feed upon carrion, but subsist entirely by stealing corn. The carrion is devoured by the birds called in South America *gallinazzi*, in Mexico *zopilots* and *aure*. By Hernandez they are said to be a species of ravens; but, according to Clavigero, they are very different, not only in their size, but in the shape of their head, their flight, and their voice.

The aquatic birds are very numerous, and of great variety.—There are at least 20 species of ducks, a vast number of geese, with several kinds of herons, great numbers of swans, quails, water rails, divers, king's fishers, pelicans, &c. The multitude of ducks is sometimes so great, that they cover the fields, and appear at a distance like flocks of sheep. Some of the herons and egrets are perfectly white, some ash-coloured; others have the plumage of the body white, while the neck, with the tops and upper part of the wings, and part of the tail, are enlivened with a bright scarlet, or beautiful blue.

Numbers of the other classes of birds are valuable for their flesh, plumage, or song, while some are remarkable for their extraordinary instinct or other properties. Clavigero enumerates more than 70 species of those which afford an agreeable and wholesome food. Besides the common fowls which were brought from the Canaries to the Antilles, and from these to Mexico, there were, and still are, fowls peculiar to the country itself. These partly resemble the common fowl and partly the peacock, whence they had the name of *gallipavos* from the Spaniards. From Mexico they were imported into Europe, where they have multiplied very fast, especially in Italy, though the common fowls have multiplied much more in Mexico.

There are great numbers of birds valuable on account of their plumage, which was made use of by the Mexicans in their excellent mosaic works; an art which seems now to be totally lost. Peacocks have been carried from the old continent to Mexico; but, not being attended to, have propagated very slowly. The birds remarkable for their song are likewise very numerous; among which that called the *centxonitl*, by Europeans the *mocking-bird*, is the most remarkable, on account of its counterfeiting naturally the notes of all others it hears. There are great numbers of beautiful parrots; and there is a bird which counterfeits the human voice, but in a kind of burlesque tone, and will follow travellers a great way. The *tzacua* is remarkable for its instinct. Birds of this kind live in society, every tree being a village or city to them, having great numbers of nests in the neighbourhood of each other, all hanging from the boughs. One of them, whose office it is to be the head or guard of the village, resides in the middle of the tree; from which it flies about from one nest to another, visiting them all, and after singing a little, returns to its place, while the rest continue perfectly silent. If any bird of a different species approaches the tree, he flies to it, and with his bill and wings endeavours to drive it off; but if a man or any large animal comes near, he flies screaming to another tree; and if at that time any of his fellows happen to be returning to their nests, he meets them, and, changing his note, obliges them to retire again: as soon as he perceives the danger over, he returns to his wonted round of visiting the nests.

Mexico, like all other American countries, abounds with reptiles, many of them of an enormous size. 116 Reptiles. The crocodiles are not less to be dreaded than those of Africa or Asia, and there are likewise some of those monstrous serpents met with in the East Indies and in South America: though happily the species of those terrible creatures seems to be nearly extinct, as they are seldom to be found but in some solitary wood, or other remote place. There are great numbers of lizards, some of which the people suppose to be poisonous; but Clavigero thinks this opinion ill-founded. There are several kinds of poisonous serpents, of which the rattlesnake is one.

The aquatic animals are innumerable. Clavigero mentions a species of frogs so large that a single one 117 Aquatic animals. will weigh a pound, and which are excellent food.—Of fish proper for food, he says that he has counted upwards of 100 species, without taking in the turtle, crab, lobster, or any other crustaceous animal. The sharks are well known for their voracity. A whole sheep's skin, and even a large butcher's knife, has been found in the belly of one of them. They are accustomed to follow vessels, to devour any filth that is thrown overboard: and, according to Oviedo, they have been known to keep up with ships sailing before a fair wind for no less than 500 miles. The bottetto is a fish about eight inches in length, but excessively thick. While this fish lies alive upon the beach, it swells whenever it is touched to an enormous size, and boys often take pleasure in making it burst with a kick. The liver is so poisonous as to kill with strong convulsions in half an hour after it is eaten.

Of flying and other minute insects, the number is 118 Insects. prodigiously great. There are a variety of beetles: some of a green colour make a great noise in flying; on which account children are fond of them. There are great numbers of shining beetles, which make a delightful appearance at night, as well as the luminous flies which abound in the country. There are six kinds of bees and four kinds of wasps; of which last, one collects wax and honey of a very sweet taste; another is called the *wandering wasp* from its frequent change of abode; and in consequence of these changes, it is constantly employed in collecting materials for its habitations. The lake of Mexico abounds with a kind of

Animals.

of fly, the eggs of which are deposited upon the flags and rushes in such quantities as to form large masses. These are collected by the fishermen, and carried to market for sale. They are eaten by both Mexicans and Spaniards, and have much the same taste as the caviare of fish. There are abundance of gnats in the moist places and lakes; but the capital, though situated upon a lake, is entirely free from them. The butterflies are in vast numbers, and their wings glow with colours far superior to those of Europe; the figures of some of them are given by Hernandez. But notwithstanding its beauties and advantages, Mexico is subject to the dreadful devastations of locusts, which sometimes occasion the most destructive famines.

There are some of the worms of Mexico made use of by the inhabitants as food; others are poisonous. There are great numbers of scolopendræ and scorpions, some of the former growing to an immense size. Hernandez says, that he has seen some of them two feet long and two inches thick. The scorpions are very numerous; and in the hot parts of the country their poison is so strong as to kill children, and give terrible pain to adults. Their sting is most dangerous during those hours of the day in which the sun is hottest. There is a mischievous kind of tick, which in the hot countries abounds among the grass. From thence it easily gets among the clothes, and from them upon the skin. There it fixes with such force, from the particular figure of its feet, that it can scarcely be got off. At first it seems nothing but a small black speck, but in a short time enlarges to such a degree, from the blood which it sucks, that it equals the size of a bean, and then assumes a leaden colour. If it is not speedily removed, a wound is made similar to that which the nigera or chegoe makes.

Mines, Manufactures, &c.

Mexico produces silk-worms: and the manufacture of silk might be carried on to great advantage, were it not prohibited for some political reasons. Besides the common silk, there is another found in the woods, very white, soft, and strong. It grows on the trees in several maritime places, particularly in dry seasons. Unless by poor people, however, this silk is not turned to any use, partly from inattention to their interests, but "chiefly (says our author) from the obstructions which would be thrown in the way of any one who should attempt a trade of that kind. We know from Cortes's letters to Charles V. that silk used to be sold in the Mexican markets; and some pictures are still preserved, done by the ancient Mexicans upon a paper made of silk."

The mines of Mexico have greatly increased in productiveness within the last forty years. They are chiefly of silver; and the ore is remarkable for its poverty; but, to balance this disadvantage, it occurs in great abundance. The whole number of persons employed under ground does not exceed 30,000, and all these are free labourers, who have high wages; the *mita tanda*, or forced labour of the Indians, having been abolished more than forty years ago. The subjoined table gives the average annual coinages of Mexico during successive periods; and, as very little bullion is exported from Mexico, the amount of the coinage expresses very nearly the produce of the mines.

	Silver Dollars.	Gold Dollars.	Total Dollars.
From 1733 to 1742, ten years,	8,998,209	434,050	9,432,259
1743 — 1752, —	11,566,030	455,109	12,021,139
1753 — 1762, —	11,971,835	462,773	12,434,603
1763 — 1771, nine years,	11,777,909	761,553	12,539,462
1772 — 1782, eleven years,	17,551,906	835,586	18,387,492
1783 — 1792, ten years,	19,491,309	644,040	20,135,340
In 1793, - -	23,428,680	884,262	24,312,942
From 1795 to 1804, ten years,	21,084,787		

More than three-fourths of the silver obtained from America is extracted from the ore by means of quicksilver; and such is the abundance of the ore in Mexico, that the only limit to the quantity of silver obtained, is the want of mercury for amalgamation. The sale of mercury is a royal monopoly: The quantity consumed annually is 16,000 quintals.

The chief manufactures of New Spain are woollens, cottons, gold and silver-lace, hats, leather, soap, and earthen-ware; but the total value of the goods they produced, when Mr Humboldt was in the country, did not exceed seven or eight millions of dollars annually. Some manufactures of silk have since been introduced; and, in general, all the manufactures, the finer sorts especially, had increased considerably, in consequence of the interruption of foreign commerce by the war. Tobacco and gunpowder are royal manufactures and monopolies; and the former brings in to the crown a clear revenue of four millions of dollars annually. The Mexican tradesmen are remarkably skilful in works of plate and jewellery; and, like some of the eastern nations, they have a singular turn for imitation. Very good carriages are made in Mexico, though the best coaches come from England.

The commerce of New Spain has increased greatly since 1765, and especially since 1778. From the first of these periods to 1789, various new edicts were issued, all tending to break down the monopoly which a few opulent merchants of Cadiz and Mexico had previously enjoyed. The average exportation from Vera Cruz, before the year 1778, when the old system subsisted, was about 617,000 piastres annually; but from

Commerce, Revenue, &c. 1787 to 1790, under the new system, it amounted to 2,840,000 piastres annually. The commerce of Mexico with the mother country, is almost entirely carried on through Vera Cruz. In time of peace, Mr Humboldt estimates the annual value of the exports in that commerce at 22,000,000 piastres, and the imports at 15,000,000. Of the former, about 17,000,000 consists of gold and silver, in coin, bullion, and plate; the other articles are cochineal, sugar, flour, indigo, salted provisions, tanned hides, sarsaparilla, vanilla, jalap, &c. Of the imports, 9,000,000 consists of bale goods, including woollens, cottons, linen, and silk. The other articles are, paper, brandy, cacao, quicksilver, iron, steel, wine, and bees-wax. This estimate does not include the imports in the contraband trade, which, in time of peace, are supposed to be about a fourth of the whole. The temptations to engage in this trade are very great, as the value of commodities imported in Spanish vessels is increased 35 or 40 per cent. by the duties. Mexico also carries on a considerable trade with Cuba, Porto-Rico, Florida, and Manilla. The whole exports are estimated at 31,500,000 piastres, including specie, and the imports at 22,000,000. The demand for foreign merchandise in New Spain and Goatemala, amounts nearly to seven millions sterling.

The revenue of New Spain has augmented with the progress of industry. In 1712 the gross revenue amounted to 3,068,400 piastres; in 1765 to 6,141,981; in 1780 to 15,010,974; and in 1802 to 20,200,000. It is derived chiefly from the following sources. From the produce of the mines, consisting of duties, profits on coinage, and on the sale of mercury, about 5,500,000 piastres. From the manufacture of tobacco, 4,000,000 to 4,500,000. From the alcavala, or duty on every sale of goods, nearly 3,000,000. From the Indian capitation, 1,300,000. From the duty on *pulque*, 800,000. From the net produce of the duty on imports and exports, 500,000. From the sale of papal indulgences, 270,000. From the post, net produce 250,000. From the sale of powder, 150,000. From clerical benefices, 100,000. From the sale of cards, 120,000. Stamp duties, 80,000. From the farm of cock-fighting, 45,000. From the farm of snow, 30,000. The expence of collection is estimated by Humboldt, on an average, at 16 or 18 per cent. of the gross receipts. Of this revenue of 20,000,000 piastres, 10,500,000 are consumed by the internal expenses of the government; 3,500,000 are remitted to other colonies to supply deficiences in their revenues; and the remainder consisting of about 6,000,000, is the clear revenue derived by the mother country from the colony. The value of the specie circulating in Mexico is estimated at fifty-five or sixty millions of piastres, which is nearly ten piastres a head for the whole population. The national wealth of Mexico is supposed to be equal to two fifths of the whole Spanish continental colonies.

The military force of the colony in 1804 consisted of 9,919 regular troops, and 22,277 militia, one half of both being cavalry. The military spirit in the militia service is partly kept up by the vanity of some families, who aspire to the titles of colonels and brigadiers. And the distribution of these titles has become a source of revenue to those individuals who have influence with the ministry. Here, as in the United States, merchants in provincial towns are transformed into colonels and majors. The petty warfare continually carried on with the wandering Indians, in the *provincias externas*, and the maintenance of the *presidios* or military posts, require a considerable expence. The state of the eastern coast, and the nature of the country, facilitate its defence against any attempt by a maritime power.

Population. In the year 1776, the old provincial divisions were laid aside, and the country was divided anew into twelve intendancies, to which must be added three districts, very remote from the capital, which have preserved the simple denomination of provinces. The whole of New Spain, in 1803, contained 118,478 square leagues, and 5,837,100 inhabitants. The population of the twelve intendancies was as follows:

Mexico, - - -	1,511,000
Puebla, - - -	813,300
Vera Cruz, - - -	156,000
Oaxaca, - - -	534,800
Merida, - - -	465,800
Valladolid, - -	467,400
Guadalaxara, - -	630,500
Zacatecas, - -	153,300
Guanaxuato, - -	517,300
San Luis Potosi, -	230,000
Old California, - -	9,000
New California, - -	15,600
Add the population of the *Provincias Internas*,	423,000
	5,837,100

This population is distinguished into different classes:

Whites,—of whom 70,000 are European Spaniards,	1,100,000
Indians, - - -	2,500,000
Mestizoes, or mixed race,	2,231,000
Negroes, - - -	6,100
	5,837,100

Of all the circumstances in the state of Spanish America, this division of its inhabitants into casts, marked by nature with differences of colour, and distinguished in law or opinion by differences of rank or privilege, is the most adverse to its happiness and prosperity. The first class is divided within itself. Though the *Gachepines*, or European Spaniards, and the Creoles, or American Spaniards, have in law equal title to preferment, the former enjoy almost all places of trust or emolument. One cause of this partiality is, that the needy court of Madrid, which has been in the practice of raising money by the sale of colonial offices, fills up even the most inferior situations. A keen spirit of jealousy is thus kept up between the parties, and the government, by showing favour to the one, has made enemies of the other.

The Mestizoes, or descendants of Spaniards and Indians, form the class next in rank after the whites. In colour they hardly differ from the Creoles; but the scantiness of their beards, the smallness of their hands and feet, and a particular cast of their eyes, betray their Indian original. Some consider them as a superior race of men to the Creoles both in bodily constitution and mental endowments. In rank they follow the condition of their fathers. The Creoles and Mestizoes

Condition and Character of the Indians.

Mestizoes form by their union, their numbers, and their property, the principal force, and the most respectable part of the Spanish colonists. As they have the same interests to maintain, and the same grievances to redress, it is probable that in the event of any civil dissensions, they would act together, whether against Indians or Europeans.

The fate of the Indians living under the Spanish government, is a striking proof of the inefficacy of law to afford protection, where those who are the objects of its care have no controul over the persons charged with its execution. The Indians are fenced by the strictest provisions against the tyranny and injustice of their rulers, and yet no people have suffered more from rapacity and oppression. They are born free, and exempt from all sorts of personal service; they are admissible into all incorporated trades, in the same manner as Spaniards; and their caciques have the privileges of Spanish nobles. Those who live in separate villages are governed by alcaldes and regidors of their own nation, and no Spaniards or mixed races are permitted to settle among them, or encroach on their lands. To prevent their facility from being abused by the fraudulent and designing, they cannot dispose of their real property without the intervention of a magistrate, nor enter into contracts, nor conclude bargains for a greater sum than three dollars. They are exempt from the alcavala, and pay only a moderate tribute,—not exceeding two dollars for every person from 10 to 50 years of age. These anxious provisions for their protection have undoubtedly operated against their progress in civilization. Their living in separate communities deprives them of the means of instruction. The state of pupilage in which they are kept destroys the energy of their characters, and detains them in perpetual childhood. The multiplicity of laws in their favour, enables the priest or magistrate to interfere when he pleases in their concerns, and, on pretext of serving them, to become their worst oppressor. The produce of the common lands of their villages, which they are bound to cultivate, is withheld from the beneficial purposes to which it is applicable by law, and openly diverted to other uses in which they have no interest or concern. The privileges of their caciques are almost illusory.

Climate has little effect on the complexion of the Indians. Those who live on the Rio Negro are darker than those who inhabit the banks of the Lower Orinoko, though they enjoy a much cooler temperature. Their children, contrary to the testimony of some authors, have a copper colour at birth. The Indians are a long lived race, when their days are not shortened by intoxication. *Pulque*, a fermented liquor from the juice of the agave americana, which is their native liquor, is less prejudicial to their health than rum or brandy, the use of which they have learned from Europeans. They have little sensibility of body, and suffer less from wounds and injuries than other casts, and they are also less subject to personal deformities. A crooked spine is never seen among them, and very few of them are squint-eyed or lame. In the provinces afflicted with the goitre, the Indians are totally exempt, and even the Mestizoes rarely suffer from that malady. Of all the races in the old world they have the greatest resemblance to the Moguls, but they have a smaller facial angle, though greater than the negro. Their skull is thicker than that of the European, the frontal bone more depressed, the occiput less protuberant, and the brain smaller. The Mexican Indian is grave, melancholy, and silent, unless when under the influence of spirituous liquors. He affects an air of mystery in the most unimportant transactions, and no expression is to be seen in his countenance of the most violent passions that agitate him. He is obstinately attached to ancient customs, manners, and opinions. He seems to be destitute of imagination, and to have little feeling; but when properly educated, has a clear head, an acute and logical understanding. The Indians are generally excessively poor, but some of them under an appearance of wretchedness conceal considerable wealth. In every village there are eight or ten individuals who live in idleness at the expence of the others, on pretence of the nobility of their birth.

Ancient Inhabitants.

119 Of the Toltecas and Chichemecas.

The Toltecas, who first inhabited Mexico, were accounted much more polished than those who came after them, insomuch that in after ages it was customary to distinguish people of ingenuity and learning by the name of Toltecas. They always lived in society, collected into cities, under the government of kings, and had regular laws. They were more addicted to the arts of peace than of war; and it was to them that the succeeding nations owed themselves indebted for their knowledge of the culture of grain, cotton, pepper, &c. They understood the art of casting gold and silver, and melting them in whatever forms they pleased, acquiring also great reputation from their skill in cutting gems of all kinds; and they were besides well versed in the sciences of astronomy and chronology.

According to the ancient histories of these people, they observed, about a hundred years before the Christian era, how far the solar year exceeded the civil one; supplying the defect, as we do, by the addition of a day once in four years. In the year 660, while their monarchy continued in Tula, a celebrated astronomer named Huematzin, assembled with the king's consent all the wise men of the nation; and with their assistance painted a famous book named *Teoamoxtli*, or "divine book," in which were represented, in very plain figures, the origin of the Indians, their dispersion after the confusion of tongues at Babel, their journey in Asia, their first settlements in America, the founding of the kingdom of Tula, and their progress till that time: but these, and other accounts of their great knowledge and accuracy, savour too much of exaggeration, or perhaps invention, from both which it is impossible to clear the Spaniards when speaking of American affairs.

120 Their progress in agriculture.

The Chichemecas derived their knowledge of agriculture from the Toltecas, and of consequence the Mexicans also. Being destitute of ploughs or animals of sufficient strength to assist them in their labour, they made use of an instrument of hard copper, which they called *coatl* or *coa*, but differing in shape either from a spade or mattock. They used copper axes to cut trees, the figure of which was the same with ours; only that they put the axe into the eye of the handle, instead of putting the handle into the eye of the axe as we do. They had several other instruments of agriculture, but the forms of them are not mentioned by historians. They watered their fields by means of the rivers

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rivers and small torrents which came from the mountains; raising dams to collect them, and forming canals to conduct them properly to the places which required moisture. They used enclosures of stone, as well as hedges for the fields, using for their hedges the aloe plant, which is well calculated for the purpose; and what reparations were necessary they gave in December. They dibbled their maize: a method of sowing more slow indeed than the ordinary one, but which certainly repays the trouble by a vastly larger crop, as well as by saving a very considerable quantity of seed. Close to the newly sown fields they commonly erected a small tower of wood, where a man kept watch, in order to drive away the birds that came to feed upon the grain; a custom still preserved among the Spaniards.

121 Magnificent gardens.

In the cultivation of their gardens, the Mexicans were extremely skilful and magnificent; planting in them not only kitchen herbs, but fruit trees, medicinal herbs, and flowers, with great taste and regularity. Some of the royal gardens excited the admiration of the Spaniards so much, that Cortes, in a letter to Charles V. informed him that the garden at Huaxtepec was the most extensive, the most beautiful, and most delightful, that had ever been beheld. It was for many years preserved by the Spaniards.——The plants most cultivated, next to maize, were cotton, cocoa, and aloe; which last served a great many useful purposes. See ALOE.

122 Tame animals.

Though they had not the advantage of the larger quadrupeds, as horses, oxen, or sheep, they bred up an immense number of quadrupeds unknown in Europe. Private persons brought up the small quadrupeds already mentioned, resembling little dogs; as well as turkeys, quails, geese, ducks, and other kinds of fowl. In the houses of the great men were bred fish, deer, rabbits, and a variety of birds; and in the royal palaces, almost all the species of quadrupeds and winged animals to be found in these kingdoms were kept, as well as a great number of aquatic animals and reptiles. According to Clavigero, Montezuma II. surpassed all the kings in the world in this kind of magnificence; and there never was a nation equal to the Mexicans in the care they took in taming animals.

123 Paintings.

Painting was an art in great request among the Mexicans, and one of very great use; as it was only by means of paintings that they recorded their histories. This art they derived, like others, from the Toltecas. Some of these paintings were mere images of their gods, kings, heroes, or terrestrial objects. Others were historical, containing an account of particular events; others mythological, of which a volume is preserved in the great library of the order of Bologna: others were codes of law, civil and religious; while some were chronological, astronomical, or astrological; in which were represented their calendar, the position of the stars, changes of the moon, eclipses, and prognostications and variations of the weather. Great numbers of these were burned by the superstitious Spaniards, who imagined that they contained some emblems of heathen worship. They had likewise geographical paintings, which served not only to show the extent and boundaries of their possessions, but likewise the situation of places, the direction of the coasts, and the course of the rivers. In his first letter to Charles V. Cortes says, that having made inquiries if there was any secure harbour for vessels on the Mexican coast, Montezuma presented him with a painting of the whole coast, from the port of Vera Cruz, at that time called *Chalchiuhuecan*, to the river Coatzacualco. Another author informs us also, that Cortes, in a long and difficult voyage which he made to the bay of Honduras, made use of a chart presented to him by the lords of Coatzacualco, in which all the places and rivers were marked from the coast of Coatzacualco to Huejacallan.

The cloth on which paintings were done was made of the thread of the aloe or a kind of palm; or they painted on sheep's skins or upon paper. This last was made of the leaves of a certain kind of aloe, steeped like hemp, and afterwards washed, stretched, and smoothed. They used also the bark of other trees, prepared with gum: but we are ignorant of the method they used in the manufacture. This paper is similar in thickness to the European pasteboard, but softer, smoother, and more easy for writing. In general it was made up in very long sheets, which they preserved in rolls, or folded like bed-skreens. The volume of Mexican paintings, preserved in the library of Bologna, is a thick skin, ill dressed, composed of different pieces painted all over, and folded up in that manner. The beautiful colours which they employed both in their paintings and in their dyes, were obtained from wood, leaves, and the flowers of different plants, as well as from various animal substances. Their white was made from a kind of stone which burns into a fine plaster; or from a mineral, which after being made into a paste worked like clay, and formed into small balls, turns white in the fire like Spanish white. Their *black* was got from another mineral, which has a disagreeable smell, or from the soot of a kind of pine collected in small earthen vessels. They obtain *blue* and *azure* colours from indigo; but their mode of obtaining these was very different from that used by the moderns. They put the branches of the plant into hot, or rather lukewarm, water; and after having stirred them about for a sufficient time with a stick or ladle, they passed the water, when impregnated with the dye, into certain pots or cups, in which they let it remain until the solid part of the dye was deposited; after which they poured off the water. This sediment was first dried in the sun, and afterwards put between two plates before a fire until it grew hard. They had another plant which likewise afforded a blue colour, but inferior to the indigo. *Red* was obtained from the seeds of the achiot or rocou, and *purple* from cochineal. Their *yellows* were ochre, and a colour extracted from the beautiful flower of a plant resembling artemisia. With nitre these flowers afforded a fine orange colour; and by means of alum they extracted other colours.

The Mexican painters were by no means arrived at much perfection in the knowledge of light and shade, or of design; nevertheless, in some of the ancient paintings, particularly in the portraits of their kings, the proportions were exactly observed. Besides paintings, however, the Mexicans are said to have employed hieroglyphics and characters; but this is absolutely denied by Clavigero; who tells us, that "they represented material things by their proper figures; but, in order to

124 They did not use hieroglyphics or characters.

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to save labour, paper, and colours, they contented themselves with representing part of an object, which was sufficient to make it understood. But as we cannot understand the writings of others till we have learned to read them; in like manner those American authors, who say that the Mexicans made use of characters, required to have been first instructed in the Mexican manner of representing objects, in order to have been able to understand the paintings which served them in place of writing. When they would represent any person, they painted a man or human head, and over it a figure expressing the meaning of his name, as appears in the figures of the Mexican kings. To express a city or village, they painted in like manner a figure which signified the same thing with its name. To form their histories or annals, they painted on the margin of the cloth or paper the figures of the years in so many squares, and at the side of each square the event or events which happened that year: and if, on account of the number of years, the history of which they meant to relate, they could not all be contained in one canvas, they were continued on another. With respect to the order of representing the years and events, it was at the liberty of the historian to begin at whichever angle of the piece he pleased; but at the same time constantly observing, that if the painting began at the upper angle of the right-hand, he proceeded towards the left; but if it began, as it most commonly did, at the upper angle of the left hand, he proceeded straight downwards. If he painted the first year at the lower angle of the left, he continued towards the right; but if he began at the lower angle of the right, he painted straight upwards; so that on the upper part of his canvas he never painted from left to right, nor ever on the lower part from right to left; never advanced upwards from the left, nor downwards from the right. When this method of the Mexicans is understood, it is easy to discover at first sight which is the beginning and which the ending of any historical painting. Their paintings, however, ought not to be considered as a regular full history, but only as monuments and aids of tradition. We cannot express too strongly the care which parents and masters took to instruct their children and pupils in the history of the nation. They made them learn speeches and discourses which they could not express by the pencil; they put the events of their ancestors into verse, and taught them to sing them. This tradition dispelled the doubts and undid the ambiguity which paintings alone might have occasioned; and, by the assistance of those monuments, perpetuated the memory of their heroes and of virtuous examples, their mythology, rites, laws, and customs.

125 Careful to preserve their traditions.

126 Preserved the memory of events by knotted threads.

"Nor did that people only make use of tradition, paintings, and songs, to preserve the memory of events, but also of threads of different colours and differently knotted. This curious method of the representation of things, however much used in Peru, does not appear to have been employed in the province of Anahuac, if not in the most early ages; for no traces of such monuments are now to be found. Boturini says, that after the most diligent search, he with difficulty found one in a place in Tlascala, the threads of which were already wasted and consumed by time. If those who peopled South America ever passed the country of Anahuac, they possibly might have left there this art, which was afterwards abandoned for that of painting, introduced by the Toltecans or some other nations still more ancient."

127 Their knowledge in sculpture.

The Mexicans arrived at greater perfection in sculpture, casting of metals, and mosaic works, than in painting. Sculpture was likewise one of the arts exercised by the ancient Toltecans; but the Mexicans had sculptors among them when they left their native country of Atztlan. Several of the Toltecan statues, however, were preserved till the time of the conquest, particularly that of the idol Tlaloc, placed upon the mountain of the same name, and some gigantic statues in one of their temples. Stone and wood were the usual materials of their statues: the former was worked with a chissel made of flint; and, in spite of the unfitness of the instrument, such was the phlegmatic nature of the people, that they surmounted every difficulty arising from the tediousness of the work. In their statues they learned to express all the attitudes and postures of which the human body is capable. They observed the proportions exactly, and could, when necessary execute the most delicate strokes with the chissel. They not only made entire statues, but cut out in wood and in stone figures in basso relievo; of which kind are those of Montezuma II. and one of his sons, recorded with praises by Acosta. They also made statues of clay and wood, employing for these a chissel of copper. The number of their statues was in proportion to that of their idols; but so active were the Spanish priests in destroying these, that there is now scarce any vestige of them remaining. The foundation of the first church in Mexico was laid with idols; on which occasion many thousand statues of their gods were necessarily broke in pieces. In casting of metals, however, the Mexicans greatly excelled their works either of painting or sculpture. "The miracles they produced of this kind (says Clavigero), would not be credible, if, besides the testimony of those who saw them, a great number of curiosities of this kind had not been sent from Mexico to Europe. The works of gold and silver sent in presents from the conqueror Cortes to Charles V. filled the goldsmiths of Europe with astonishment; who, as several authors of that period attest, declared that they were altogether inimitable. The Mexican founders made both of gold and silver the most perfect images of natural bodies. They made a fish in this manner, which had its scales alternately one of silver and the other of gold; a parrot with a moveable head, tongue, and wings; and an ape with a moveable head and feet, having a spindle in its hand in the attitude of spinning. They set gems in gold and silver, and made most curious jewellery of great value. In short, these sorts of works were so admirably finished, that even the Spanish soldiers, all stung with the same wretched thirst for gold, valued the workmanship above the materials. This wonderful art, formerly practised by the Toltecas, the invention of which they ascribed to one of their gods, has been entirely lost by the debasement of the Indians, and the indolent neglect of the Spaniards. We are doubtful if there are any remains of those curious works; at least we apprehend that it would be more easy to find them in some of the cabinets of Europe than in all New Spain. Covetousness to profit by the materials must unquestionably have conquered all desire to preserve them as curiosities." The works of the Mexicans in gold and silver, executed

128 Excelled in the art of casting metals.

executed with the hammer, were much inferior to those of the Europeans.

But of all the works executed by the ancient Mexicans, those of mosaic were the most curious, as well as
129 Beautiful mosaic. most highly valued by themselves. These were made of the feathers of birds; and for procuring them they reared a great number of those birds of fine plumage, with which the country abounded, not only in the royal palaces, but also in private houses; and at certain seasons they carried off the feathers for these purposes, or to sell them at market. They valued particularly the feathers of the humming birds, on account of their smallness, fineness, and various colours; and in these, as well as other birds of fine plumage, nature supplied them not only with all the colours produceible by art, but likewise with many which art cannot imitate. Their mosaic works, as well as indeed all others of the Mexicans, required infinite patience. At the undertaking of every work of this kind several artists assembled; and having agreed upon a design, and fixed their measure and proportions, each artist charged himself with the execution of a certain part of the image, and exerted himself so diligently in it, that he frequently spent a whole day in adjusting a feather; first trying one and then another, viewing it sometimes one way, then another, until he found one which gave his part that ideal perfection proposed to be attained. When the part which each artist undertook was done, they assembled again to form the entire image from them. If any part happened to be in the least deranged, it was wrought again until it was perfectly finished. They laid hold of the feathers with small pincers, that they might not do them the least injury, and pasted them on the cloth with some glutinous matter; then they united all the parts upon a little table or a plate of copper, and flattened them softly until they left the surface of the image so equal and smooth, that it appeared to be the work of a pencil. These works were prodigiously admired by the Spaniards.

130 Their architecture. The Mexicans were skilled in architecture even before they left their native country; and many edifices still remain which were constructed by them during their frequent journeys from one place to another. At their first arrival on the lake, they had no other materials to build their houses with but reeds and mud, until the success of their commerce allowed them to purchase better materials. When the city came to its perfection, the houses of the principal people were constructed of stone and lime: they consisted of two floors, having halls, large court-yards, and chambers fitly disposed: the roofs were flat and terraced; the walls so well whitened, polished, and shining, that they appeared to the Spaniards when at a distance to have been constructed of silver. The floor was paved with plaster, perfectly level, plain, and smooth. Many of their houses were crowned with battlements and turrets; and their gardens had fish ponds, and the walks of them symmetrically laid out. The large houses had in general two entrances, the principal one to the street, the other to the canal: they had no wooden doors to their houses, but covered the entrance with small reeds, from whence they suspended a string of cocoa shells, or some other materials which would make a noise, so as to awake the attention of the family when any person lifted up the reeds to enter the house. —The houses of the poorer sort were constructed of reeds, unburnt bricks, stone, or mud; and the roofs made of a kind of a long hay which grows plentifully in the fields, particularly in the warm parts of the country. For this purpose they used also the leaves of the aloe placed in the manner of tiles, to which they bear some resemblance both in thickness and shape. One of the columns or supports of these houses was generally a tree in the vigour of its growth; by which means, besides the pleasure derived from its foliage and shade, they saved themselves some labour and expence. These houses had one or more apartments according to the circumstances of the family.

The ancient Mexicans understood the method of constructing arches or vaults, as appears from some remains of their buildings as well as from their paintings. They had likewise cornices and other ornaments of architecture. They had also square or cylindrical columns; but it is not known whether they had any capitals or not. They frequently adorned them with figures in *basso relievo;* but their great ambition was to have them all made out of one stone. The foundations of the large houses in the capital were laid upon beams of cedar driven into the ground, on account of its want of solidity; and the same method is still practised by the Spaniards. The roofs of these were made of cedar, fir, cypress, pine, &c. In the royal palaces the columns were of marble or even of alabaster, which the Spaniards mistook for jasper. In the reign of Ahuizotl a new kind of stone, named *tetzontli*, was discovered in the Mexican lake, which was ever afterwards made use of for building. It is hard, light, and porous like a sponge; by which means the lime adheres very firmly to it. It is valued likewise on account of its colour, which is a blood red. Some of the pavements were chequered with marble and other valuable stones.

The most remarkable pieces of Mexican architecture 131 Remarkable aqueducts.
were their aqueducts. There were two which conveyed the water to the capital from the distance of two miles. These were constructed of stone and cement, five feet high, and two paces broad, upon a road for that purpose upon the lake; by which the water was brought to the entrance of the city, from whence it was sent forth in smaller channels to supply the different fountains. The famous aqueduct of Chempoallan, which was done in the 16th century, is worthy of being ranked among the greatest in Europe. The conductor of this work was a Franciscan missionary named *Tembleque;* and it was executed with great skill by the Chempoallese. The water was brought from a great distance, and the country through which it must pass was mountainous and rocky; but every difficulty was overcome by the industry of the Mexicans. The aqueduct, including all the turnings and windings, exceeded 30 miles in length. The principal difficulty consisted in crossing three great precipices, over which they were obliged to construct three bridges, the first of 47, the second of 13, and the third of 67 arches. The largest arch was 100 feet high, and 61 broad; so that a large vessel could have passed under it. It must, however, be observed, that, in executing this undertaking, the Mexicans were undoubtedly assisted by European

European tools, and the directions of European workmen; so that we cannot with strict propriety call it one of their works.

132 Excellent jewellers. They were expert jewellers, and understood the art of cutting and polishing the stones, as well as of setting them. The gems most common in their country were the emeralds, amethysts, carnelians, turquoises, and some others. Emeralds were so common, that no lord or noble wanted them; and none of them died without having one fixed to his lip, that it might serve him, as they imagined, in the other world, instead of a heart. When Cortes returned the first time to Spain, he brought with him five emeralds, valued, by the jewellers there, at 100,000 ducats. The first was in the form of a rose; the second of a horn; the third of a little fish with eyes of gold; the fourth in the form of a bell, with a fine pearl for a clapper. The fifth was a small cup with a foot of gold, and four little golden chains which united in a pearl in the form of a button. For this alone the Genoese merchants offered 40,000 ducats, in order to sell it again to the grand signior. Besides these, he had two emerald vases valued at 300,000 ducats; but these last were lost by shipwreck in the unfortunate expedition of Charles V. against Algiers. There are no such gems wrought at present, nor is it even known where the emerald mines are situated; though it is said there are still some large pieces of this precious stone in some of the churches; but the priests take care to secure them with iron chains, lest they should be carried off.

133 Manufactures of different kinds. In other more common manufactures the Mexicans were by no means deficient. The earthen ware of Cholula was much praised by the Spaniards; and they had the art of ornamenting this kind of ware with various colours, though they did not understand the making of glass. Their carpenters wrought with instruments of copper; and there are still remains of their labours which display a tolerable skill. Almost every one was acquainted with the method of making cloth. Being destitute of wool, common silk, lint, or hemp, they were obliged to supply the deficiency by other materials. For wool they substituted cotton, for silk they used feathers, the wool of the hare or rabbit; and instead of lint and hemp, they used the fibrous part of the leaves of the aloe. From these last they obtained a thread as fine as from lint; and from some species they had a coarser sort resembling hemp. To obtain this thread they soaked the leaves in water, cleaned them, exposed them to the sun, and then beat them till they were fit to be spun. Sometimes they interwove with their cotton the finest down on the belly of the rabbits or hares, after having spun it into thread; and of these they made most beautiful cloths, which were particularly used for winter waistcoats for the lords. Their cotton manufactures were equal to any produced in Europe; they wove them with different figures and colours, representing different animals and flowers. Of feathers interwoven with cotton they made mantles and bed-curtains, carpets, gowns, &c. These were exceedingly beautiful; but this kind of manufacture is now lost, though there are still some of these garments in the possession of the principal lords, who wear them upon solemn occasions.

134 Their horrible religion. All these advances towards civilization, however, in the ancient Mexicans, were much more than counterbalanced by the horrible barbarities they committed in their religious ceremonies, and in which they exceeded every nation on earth. Human sacrifices were indeed in use among all the ancient heathens; but such prodigious massacres at the dedication of their temples are unheard of in history. Whether they used these barbarous sacrifices in their own country, or whether the practice began with that of the four Xochimilca prisoners, is not known; but as they only used their prisoners or slaves whom they bought in this way, it is impossible that, during the infancy of their state, the number of human victims could have been very great. Most of those unhappy creatures perished by having their breasts opened, and their hearts pulled out; some were drowned, others starved to death with hunger; and sometimes they were burnt. Prisoners of high rank were allowed to die by what Clavigero calls the *gladiatorian* sacrifice, which was performed in the following manner: Near to the greater temple of large cities, in an open space of ground sufficient to contain an immense number of people, was a round terrace eight feet high, upon which was placed a large round stone resembling a millstone in shape, but much larger, almost three feet high, well polished, and having figures cut upon it. On this stone, which was called *temalcatl*, the prisoner was placed, armed with a shield and short sword, and tied by one foot. Here he was encountered by a Mexican officer or soldier better armed than himself. If the prisoner was vanquished, he was carried, dead or alive, to the temple, where his heart was taken out and offered in the usual manner; but if he conquered six combatants, he gained his life and liberty. An instance, however, is given in which this custom was infringed; for the Huetzotzincas having taken the principal lord of Cholula, a man of singular bravery, he overcame seven combatants; notwithstanding which he was put to death; but on this account the Huetzotzincas were rendered for ever infamous among these nations. 135 Gladiatorian sacrifice.

136 Number of human victims annually sacrificed. Historians differ concerning the number of victims who perished annually in these sacrifices: Clavigero inclines to think it was 20,000, but others make it much more. Zumarraga, the first bishop of Mexico, says in a letter of the 12th of June 1531, addressed to the general chapter of his order, that in that capital alone there were above 20,000 victims annually sacrificed. Some authors, quoted by Gomara, say that 50,000 were annually sacrificed in the various parts of the empire. Acosta says, that there was a certain day of the year on which they sacrificed 5000 victims, and another on which 20,000 were sacrificed. According to others they sacrificed, on the mountain Tepeyacac only, 20,000 annually to one of their female deities. On the other hand, Bartholomew de las Casas reduces the number of human victims to 50 or at most to 100. "We are strongly of opinion (says Clavigero), that all these authors have erred in the number; Las Casas by diminution, and the rest by exaggerating the truth."

137 Their monstrous austerities. Besides the cruelties which they practised upon others, the Mexicans were accustomed to treat themselves with the most inhuman austerities, thinking that the diabolical rage of their deities would be appeased by human blood. "It makes one shudder (says Clavigero), to read the austerities which they practised upon themselves, either in atonement for

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for their transgressions, or in preparation of their festivals. They mangled their flesh as if it had been insensible, and let their blood run in such profusion as if it had been a superfluous fluid in the body. The effusion of blood was frequent and daily with some of their priests. They pierced themselves with the sharpest spines of the aloe, and bored several parts of their bodies, particularly their ears, lips, tongue, and the fat of their arms and legs. Through the holes which they made with these spines they introduced pieces of cane, the first of which were small; but every time this penitential suffering was renewed, a thicker piece was made use of. The blood which flowed from them was carefully collected in the leaves of the plant *aczojatl*. They fixed the bloody spines in little balls of hay, which they exposed upon the battlements of the walls of the temple, to testify the penance which they did for the people. Those who exercised such severities upon themselves within the enclosure of the greater temple of Mexico, bathed in a pond that was formed there, and which, from being always tinged with blood, was called *ezapan*."

138 Their dress.

The dress of the Mexicans was very simple; that of the men consisted only of a large belt or girdle, the two ends of which hung down before and behind; the women wore a square mantle, about four feet long; the two ends were tied upon the breast or upon one shoulder. The Mexican gown was also a piece of square cloth, in which the women wrapped themselves from the waist down to the middle of the leg. They wore also a small under vest or waistcoat without sleeves, named *huepilli*.

The dress of the poorer sort was made of the thread of the mountain palm, or of coarse cotton: but those of better station wore the finest cotton, embellished with various colours, and figures of animals or flowers; or woven with feathers, or the fine hair of the rabbit, &c. The men wore two or three mantles, and the women three or four vests, and as many gowns, putting the longest undermost, so that a part of each of them might be seen. Their shoes were only soles of leather, or coarse cloth of the mountain palm tied with strings; but those of the great people were adorned with ribbands of gold and jewels. They all wore long hair, and thought themselves dishonoured by being shaved, or having their hair clipped, except the consecrated virgins in the temple. The women wore it loose; but the men tied it up in different forms, and adorned their heads with fine feathers, both when they danced and went to war. With this simplicity, however, they mixed no small quantity of extravagance. Besides feathers and jewels, with which they used to adorn their heads, they wore ear-rings, pendants at their upper lip, as well as many at their noses, necklaces, bracelets for the hands and arms, as well as certain rings like collars which they wore about their legs. The ear-rings of the poor were shells, pieces of crystal, amber, &c.; but the rich wore pearls, emeralds, amethysts, or other gems set in gold.

Instead of soap the Mexicans used a kind of fruit called *copalxocotl*; the pulp of which is white, viscous, and very bitter, makes water white, raises a froth, and will clean linen like soap. They used also a kind of root named *amolli*, which is not unlike the *saponaria* of the old continent. It is now more used for washing the body, especially the head than for clothes. Clavigero says, that there is a kind of this root which dyes the hair of a golden colour, and that he has been witness to this effect on the hair of an old man.

139 Mexicans cruelly treated by the Spaniards.

It is generally believed, that the first conquerors massacred the Indians out of wantonness, and that even the priests incited them to these acts of ferocity. Undoubtedly these inhuman soldiers frequently shed blood without even an apparent motive; and certainly their fanatic missionaries did not oppose these barbarities as they ought to have done. The cruelties exercised upon them, however, at length raised up a protector for them in the person of Bartholomew de las Casas.

140 Bartholomew de las Casas takes their part.

This man, so famous in the annals of the new world, had accompanied his father in the first voyage made by Columbus. The mildness and simplicity of the Indians affected him so strongly, that he made himself an ecclesiastic, in order to devote his labours to their conversion. But this soon became the least of his attention. As he was more a *man* than a *priest*, he felt more for the cruelties exercised against them than for their superstitions. He was continually hurrying from one hemisphere to the other, in order to comfort the people for whom he had conceived an attachment, or to soften their tyrants. This conduct, which made him be idolized by the one and dreaded by the other, had not the success he expected. The hope of striking awe, by a character revered among the Spaniards, determined him to accept the bishoprick of Chiapa in Mexico. When he was convinced that this dignity was an insufficient barrier against that avarice and cruelty which he endeavoured to check, he abdicated it. It was then that this courageous, firm, disinterested man, accused his country before the tribunal of the whole universe. In his account of the tyranny of the Spaniards in America, he accuses them of having destroyed 15,000,000 of Indians. They ventured to find fault with the acrimony of his style; but no one convicted him of exaggeration. His writings, which indicate the amiable turn of his disposition, and the sublimity of his sentiments, have stamped a disgrace upon his barbarous countrymen, which time hath not, and never will, efface.

141 Their condition rendered somewhat easier.

The court of Madrid, awakened by the representations of the virtuous Las Casas, and by the indignation of the whole world, became sensible at last, that the tyranny it permitted was repugnant to religion, to humanity, and to policy; and resolved to break the chains of the Mexicans. Their liberty was now only constrained by the sole condition, that they should not quit the territory where they were settled. This precaution owed its origin to the fear that was entertained of their going to join the wandering savages to the north and south of the empire.

The city of Mexico is situated in a valley of the same name, which is of an oval form, about 67 leagues in circumference, and bounded by mountains. The lakes, five in number, occupy about one tenth of the surface of the valley. The city is now about a mile distant from the west side of the lake Tezcuco, which surrounded it in the time of Cortes. The soil on which it stands is about 7200 feet above the sea, a height exceeding

Cities.

ceeding that of the pass of St Gothard. Mexico is one of the finest cities ever built by Europeans in either hemisphere. The ground is very level, the streets broad and regular, the style of the architecture is generally pure, and some of the buildings truly beautiful. The streets have foot pavements, and are kept clean and well lighted by an excellent police. Among the objects worthy of notice are the cathedral, the treasury, the convent of St Francis, the hospital, the school of mines with its fine collections in physics, mechanics, and mineralogy, the botanic garden, the university, and academy of fine arts, the equestrian statue of Charles IV. of great beauty and colossal size, weighing 450 quintals, and made by a native artist. The most considerable monuments of ancient Mexican art remaining are two pyramids on the north-east side of the lake Tezcuco, the larger of which has at present a base of 682 feet in length, with an elevation of 180. The faces of these pyramids correspond with considerable exactness to the cardinal points of the compass. The population of the city in 1803 was about 137,000, of which 2500 were Europeans, 65,000 white Creoles, 33,000 Indians, 26,500 Mestizoes, and 10,000 Mulattoes. The convents contain about 1200 men, and 2100 women. The clergy of the city exceed 2000, exclusive of lay brothers and novices. The whole intendancy of Mexico contains 5927 square leagues. The only considerable towns in it beside the capital, are Queretaro containing 35,000 inhabitants, and the port of Acapulco, on the South sea, containing 9000.

The most considerable cities in the other parts of New Spain are, La Puebla, containing 67,000 inhabitants; Guanaxuato, which contains, including the rich mines in its neighbourhood, 70,000 inhabitants; Zacatecas, also situated in a rich mining district, contains 33,000; Oaxaca, 24,000; Vera Cruz, the principal port in the colony, but unhealthy in its situation, has only a population of 16,000.

The population of New Spain is in a state of rapid increase, as appears from the registers of births and burials, which are kept in many places with great accuracy. The proportion of births to deaths throughout the kingdom, is as 170 to 100. In some part of the table land the proportion is as high as 253 to 100; but at Panuco on the coast of the North sea, it was as low as 123 to 100.

A very great inequality of fortune prevails in Mexico. The count of Valenciana enjoys an income of about 100,000l. sterling per annum, of which three fourths are derived from his mine. The marquis of Fagoaga drew 83,000l. sterling, from a single mine in six months. The count of Regla built two first-rate men of war, at his own expence, and made a present of them to his sovereign. Close to this wealth is to be seen the most wretched poverty. In the city of Mexico alone, there are from 20,000 to 30,000 Sarugates and Guachinangoes, who can be compared only to the Lazaroni of Naples. Quiet, sober, and indolent, they give occasion to no alarm, though they are half naked, and pass the night in the street, under the canopy of heaven. This inequality of condition exists equally among the clergy. The archbishop of Mexico has a revenue of 130,000 dollars; there are four bishops whose revenues are from 80,000 to 110,000 each, while many of the parish clergy have not above 100 dollars a year. The whole Mexican clergy including lay brothers and sisters, does not exceed 13,000 or 14,000. The revenues arise chiefly from tithes, the church lands being inconsiderable.

Volcanoes and Insurrection.

There are five burning volcanoes in New Spain, Orizaba, Popocatepetl, Tustla, Jorullo, and Colima. The second of these is 17,700 feet in height, which is 2000 feet higher than Mount Blanc. It is situated at the south-east extremity of the valley of Mexico, and is visible from the capital. The Pic d' Orizaba has nearly the same elevation. The mountain Jorullo, which rises 1690 feet above the surrounding plains, was thrown up by a volcanic eruption in 1759. Several of these mountains, and some others that seem to be extinguished volcanies, ascend beyond the inferior limit of perpetual snow, which has here an elevation of 8360 feet. The snow is carried to Mexico and other cities, where it is sold, and pays duty as an article of luxury. Vera Cruz is supplied from the volcano of Orizaba, at the distance of 28 leagues, over which space the snow is carried on the backs of mules.

The extraordinary events in Old Spain, which produced revolutions in some of the other American colonies, also led to an insurrection in Mexico. An extensive conspiracy was formed, at the head of which were some ecclesiastics and military officers; but the secret was betrayed, and the conspirators were prematurely driven to take up arms in September 1810. They were under the command of Hidalgo a priest; and having been joined by some parties of cavalry and infantry, they got possession of Guanaxuato, a large town. Great numbers declared for them in all parts of the country. After defeating some divisions of military, Hidalgo advanced to the neighbourhood of the capital; but discouraged by the means of defence which the new viceroy had collected, and hearing of the defeat of some of his adherents in other quarters, he retired. He was followed by a considerable military force, routed in several engagements, great part of his troops, who consisted chiefly of Indians without firelocks, were dispersed, and himself taken and shot in July 1811. His partizans, however, under Morelos continued the war, and gained occasional successes. Zitaquaro, a city containing 10,000 inhabitants, in which they had established themselves, was taken by the royalists, and utterly rased in the beginning of 1812. In the same year the insurgents were joined by Toledo, who had been a member of the cortes for Spanish America, and brought with him a few troops from the United States; but he was soon compelled to seek safety in flight. In 1814 the insurgents called a congress, which issued a democratic constitution in October. In 1815 Morelos when marching to the coast to join Toledo and General Humbert, who had brought a supply of arms, was surprised, taken prisoner, and shortly after executed. His death broke the strength of the insurgents, though guerilla parties still traversed the country. In 1816 a new attempt was made by Colonel Mina, who had distinguished himself in the wars in the peninsula. He landed at Matagorda, and appears to have made some progress at first; but was finally surrounded and taken by the royal troops in November 1817. The new viceroy Apodaca, by following a

Insurrection. a lenient and conciliatory system, has restored some degree of order and quiet to the colony; but bands of guerillas still maintain themselves in different parts, and interrupt the communications between the capital and the sea coast. See article MEXICO, SUPPLEMENT.

New Mexico. MEXICO, NEW, so called because it was discovered later than Old Mexico, a country of North America, lying on the eastern side of the northern Andes, or Stony mountains, and extending from the 31st to the 38th degree of latitude. Its length from north to south is 175 leagues, and its breadth from east to west from 30 to 50. Its surface covers 5700 square leagues, and it contained in 1803 40,200 inhabitants according to Humboldt. It is fertile, but is believed to be destitute of metallic wealth. It is watered through its whole extent by the Rio del Norte, the banks of which are picturesque, and are adorned with beautiful poplars, and other trees peculiar to the temperate zone.

Though under the same latitude with Syria and central Persia, this country has a remarkably cold climate. Near Santa Fe, and a little further north, the Rio del Norte is sometimes covered for a succession of several years with ice thick enough to admit the passage of horses and carriages. The mountains which bound the valley of the Rio del Norte, lose their snow towards the beginning of the month of June.

The Rio del Norte has a periodical swell like the Mississippi. Its waters, which are always muddy, begin to rise in April, are at their height in May, and fall towards the end of June. The inhabitants can only ford the river on horses of an extraordinary size, during the drought of summer. Humboldt informs us that in 1752, the whole bed of this river, for more than 30 leagues above and 20 leagues below Passo del Norte, became dry of a sudden, the water having precipitated itself into a newly formed chasm, and only made its re-appearance near the Presidio de San Eleazario; at length, after the lapse of several weeks, the water resumed its ancient course, no doubt because the chasm and the subterraneous conductors had been filled up. In the northern part of New Mexico, rivers take their rise which run into the Mississippi.

The colonists of this province, known for their great energy of character, live in a state of perpetual warfare with the neighbouring Indians. It is on account of this insecurity of the country life, that we find the towns more populous than we should expect in so desert a country. Some commercial intercourse exists however, between the whites and the Indians, and it is carried on in a singular manner. The savages plant upon the road from Chihuahua to Santa Fe, small crosses, to which they suspend a leathern pocket, with a piece of stag's flesh; and below a buffalo's hide is stretched. The Indian indicates by these signs that he wishes to exchange hides for provisions with the men who adore the cross. The soldiers of the Presidios, who understand these signs, take away the buffalo hide and leave some salted flesh at the foot of the cross. This system of commerce indicates at once an extraordinary mixture of good faith and distrust.

The Indians to the west of the Rio del Norte are in a much less barbarous state than the wandering tribes on the east. Father Garces who visited the country of the Moqui in 1773, was surprised to find an Indian town with two great squares, houses of several stories, and streets well laid out and parallel to one another. Here, and in other points on the west coast, every thing appears to announce traces of the cultivation of the ancient Mexicans.

The province of New Mexico contains 3 towns, 26 villages, 3 parishes, 19 missions, and no solitary farm. Santa Fe the capital, has a population of 3600; Albuquerque 6000, and Taos 8900.

New Mexico, Mezeray. MEZERAY, FRANCIS EUDES DE, an eminent French historian, the son of Isaac Eudes a surgeon, was born at Rye, in Lower Normandy, in 1610; and took the surname of *Mezeray*, from a hamlet near Rye. Having performed his studies at Caen, he discovered a strong inclination to poetry; but going to Paris, he, by the advice of one of his friends, applied himself to the study of politics and history, and procured the place of commissary at war, which he held for two campaigns. He then shut himself up in the college of St Barbe, in the midst of books and manuscripts; and, in 1643, published the first volume of the History of France, in folio; and some years after, the other two volumes. Mezeray in that work surpassed all who had written the history of France before him, and was rewarded by the king with a pension of 4000 livres. In 1668, he published an Abridgement of his History of France, in three volumes 4to, which was well received by the public; but as he inserted in that work the origin of most of the taxes, with very free reflections, M. Colbert complained of it, when Mezeray promised to correct what he had done in a second edition; but those corrections being only palliations, the minister caused half of his pension to be suppressed. Mezeray complained of this in very severe terms; when he obtained no other answer than the suppression of the other half. Vexed at this treatment, he resolved to write on subjects that could not expose him to such disappointments; and composed his treatise on the origin of the French, which did him much honour. He was elected perpetual secretary to the French academy; and died in 1683. He is said to have been a man extremely negligent in his person, and so careless in his dress, that he might have passed for a begger rather than for what he was. He was actually seized one morning by the *archers des pauvres*, or parish officers; which mistake was so far from provoking him, that he was highly diverted with it, and told them, that "he was not able to walk on foot, but that as soon as a new wheel was put to his chariot, he would attend them wherever they thought proper." He used to study and write by candle light, even at noon-day in summer; and, as if there had been no sun in the world, always

always waited upon his company to the door with a candle in his hand. With regard to religion, he affected Pyrrhonism; which however was not, it seems, so much in his heart as in his mouth. This appeared from his last sickness; for having sent for those friends who had been the most usual witnesses of his licentious talk about religion, he made a sort of recantation, which he concluded with desiring them "to forget what he might formerly have said upon the subject of religion, and to remember, that Mezeray dying was a better believer than Mezeray in health." Besides his history, he also wrote, 1. A continuation of the history of the Turks. 2. A French translation of John de Salisbury's Latin treatise on the vanities of the court. 3. There are attributed to him several satires against the government; and in particular, those that bear the name of *Sandricourt*.

MEZIERS, a strong town of France, in the department of Ardennes, with a citadel. It was besieged with a powerful army by Charles V. who was obliged to raise the siege in 1521. It is seated on the river Maese, partly upon a hill, and partly in a valley, in E. Long. 4. 48. N. Lat. 49. 46.

MEZIRIAC, CLAUDE GASPAR BACKET SIEUR DE, one of the most ingenious men of the 17th century, was born at Bresse, of an ancient and noble family. He was a good poet in French, Italian, and Latin; an excellent grammarian, a great Greek scholar, and an admirable critic. He was well versed in the controversies, both in philosophy and religion; and was deeply skilled in algebra and geometry, of the former of which he gave proof by publishing the six books of Diophantus, enriched with a very able commentary and notes. In his youth he spent a considerable time at Paris and at Rome; at which last place he wrote a small collection of Italian poems, in competition with Vaugelas, who was there at the same time; among which there are imitations of the most beautiful similes contained in the first eight books of the Æneid. He also translated Ovid's Epistles; a great part of which he illustrated with very curious commentaries of his own. Whilst he was at Paris, they talked of making him preceptor of Louis XIII. upon which he left the court in great haste, and afterwards declared that he had never felt so much pain upon any occasion of his life; for he seemed to have already upon his shoulders the important weight of the whole kingdom. He undertook the translation of all Plutarch's works, with notes; which he had brought nearly to a conclusion, when he died at Bourg, in Bresse, anno 1638, at 45 years of age. He left behind him several finished works, that were not printed.

MEZUZOTH, in the Jewish customs, certain pieces of parchment, which the Jews fix to the door-posts of their houses, taking that literally which Moses commands them, saying, "Thou shalt never forget the laws of thy God, but thou shalt write them upon the posts of thy house, and on thy gates." This expression means nothing else, but that thou shalt always remember them, whether thou comest into thy house or goest out. But the Hebrew doctors imagined, that the lawgiver meant something more than this. They pretended that, to avoid making themselves ridiculous, by writing the commandments of God without their doors, or rather to avoid exposing themselves to the profanation of the wicked, they ought at least to write them on a parchment, and to enclose it in something. Therefore they wrote these words upon a square piece of parchment prepared on purpose, with a particular ink, and in a square kind of character. Deut. vi. 4, 5, 6, 7, 8, 9. "Hear, O Israel, the Lord our God is one Lord," &c.—Then they left a little space, and afterwards went on, Deut. xi. 13. "And it shall come to pass if thou shalt hearken diligently to my commandments," &c. as far as, "Thou shalt write them upon the door-posts of thy house," &c. After this they rolled up the parchment, and put it into a case of reeds or other matter; they wrote on the end of the case the word *Shaddai*, which is one of the names of God; and they put it at the doors of their houses, chambers, and all places most frequented; they fixed it to the knockers of the door, on the right side; and as often as they entered in or went out they touched it in this place, with the end of their finger, which they afterwards kissed out of devotion. The Hebrew word *mezuza* properly signifies the door-posts of a house; but it is also given to this roll of parchment now mentioned.

MEZZOTINTO, a particular manner of representing figures on copper, so as to form prints in imitation of painting in Indian ink. See ENGRAVING.

The invention of this art has been usually attributed to Prince Rupert. But Baron Heinikin, a very judicious and accurate writer upon the subject of engraving, asserts, with great appearance of truth, that it was a lieutenant-colonel de Siegan, an officer in the service of the landgrave of Hesse, who first engraved in this manner: and that the print which he produced was a portrait of the princess Amelia Elizabeth of Hesse, engraved in the year 1643. Prince Rupert learned the secret from this gentleman, and brought it into England when he came over the second time with Charles II. Prince Rupert's print of An Executioner holding a Sword in one Hand and a Head in the other, a half length, from Spagnoletto, is dated 1658. This art has never been cultivated with success in any country but England.

The prince laid his grounds on the plate with a channelled roller: but one Sherwin, about the same time, laid his grounds with a half-round file, which was pressed down with a heavy piece of lead. Both these grounding tools have been laid aside for many years; and a hand tool, resembling a shoe-maker's cutting board knife, with a fine crenelling on the edge, was introduced by one Edial, a smith by trade, who afterwards became a mezzotinto painter.

It is very different from the common way of engraving. To perform it, they rake, hatch, or punch, the surface of the plate all over with a knife, or instrument made for the purpose, first one way, then the other, across, &c. till the surface of the plate be thus entirely furrowed with lines or furrows, close and as it were contiguous to each other; so that, if an impression was then taken from it, it would be one uniform blot or smut. This done, the design is drawn or marked on the same face; after which, they proceed with burnishers, scrapers, &c. to expunge and take out the dents or furrows, in all parts where the lights of the piece are to be; and that more or less as the lights are to be stronger or fainter; leaving those parts

Mezzotinto.

parts black which are to represent the shadows or deepenings of the draught.

As it is much easier to scrape or burnish away parts of a dark ground corresponding with the outline of any design sketched upon it, than to form shades upon a light ground by an infinite number of hatches, strokes, and points, which must all terminate with exactness on the outline, as well as differ in their force and manner; the method of scraping, as it is called, in mezzotinto, consequently becomes much more easy and expeditious than any other method of engraving. The instruments used in this kind of engraving are cradles, scrapers and burnishers.

In this engraving, the plate must be prepared and polished in the same manner as for other engraving; and afterwards divided equally by lines parallel to each other, and traced out with very soft chalk.—The distance of these lines should be about one-third of the length of the face of the cradle which is to be used, and these lines should be marked with capital letters, or strokes of the chalk. The cradle is then to be placed exactly betwixt the two first lines, and passed forwards in the same direction; being kept as steady as possible, and pressed upon with a moderate force. The same operation must be repeated with respect to all other lines; till the instrument has thus passed over the whole surface of the plate.—Other lines must be then drawn from the extremities of the other two sides, in the same manner; which, intersecting the first at right angles, will with them form squares; and the same operation must be repeated with the cradle as in the case of the first. New lines must then be drawn diagonally, and the cradle passed betwixt them as before; and when the first diagonal operation is performed, the lines must be crossed at right angles as the former, and the cradles passed betwixt them in the same manner.—The plate having undergone the action of the cradle, according to the disposition of the first order of lines, a second set must be formed, having the same distances from each other as the first. But they must be so placed as to divide those already made into spaces one-third less than their whole extent; i. e. every one after the first on each side will take in one-third of that before it, e. g. beginning at A, of which the first third must be left out; a third of B will consequently be taken in, and so of the rest. These lines of the second order must be marked with small letters, or lesser strokes, to distinguish them from the first: and the same treatment of the plate must be pursued with respect to them as was practised for the others. When this second operation is finished, a third order of lines must be made, the first of which, e. g. in A, must omit two-thirds of it, and consequently take in two-thirds of B, &c. By these means, the original spaces will be exactly divided into equal thirds; and the cradle must be again employed betwixt these lines as before.—When the whole of this operation is finished, it is called *one turn;* but in order to produce a very dark and uniform ground, the plate must undergo the repetition of all these several operations for above twenty times; beginning to pass the cradle again betwixt the first lines, and proceeding in the same manner through all the rest. When the plate is prepared with a proper ground, the sketch must be chalked on it, by rubbing the paper on the backside with chalk. It is also proper to overtrace it afterwards with black lead or Indian ink. The scraping is then performed, by paring or cutting away the grain of the ground in various degrees; so that none of it is left in the original state except in the touches of the strongest shade. The general manner of proceeding is the same as drawing with white upon black paper. The masses of light are first begun with; and those parts which go off into light in their upper part, but are brown below: the reflections are then entered upon; after which the plate is blackened with a printer's blacking ball made of felt, in order to discover the effect: and then the work is proceeded with; observing always to begin every part in the places where the strongest lights are to be.

The art of scraping mezzotintos has been applied to the printing with a variety of colours, in order to produce the resemblance of paintings. The inventor of the method of doing this was J. C. Le Blon, a native of Frankfort, and pupil of Carlo Marata, between the years 1720 and 1730. It was established by the inventor on this principle, that there are three primitive colours, of which all the rest may be composed by mixing them in various proportions; that any two of these colours being mixed together, preserve their original power, and only produce a third colour such as their compound must necessarily give; but if transparent colours be mixed, and three primitive kinds compounded together, they destroy each other, and produce black, or a tendency to it, in proportion to the equality or inequality of the mixture; and that if, therefore, these three colours be laid, either separately or upon each other, by three plates, engraved correspondently on these principles to the colouring of the design, the whole variety of teints necessary may be produced. The requisites, therefore, to the execution of any design in this method of printing are as follows: 1. To settle a plan of the colouring to be imitated; showing where the presence of each of the three simple colours is necessary, either in its pure state or combined with some other, to produce the effect required; and to reduce this plan to a painted sketch of each, in which not only the proper outlines, but the degree of strength should be expressed. 2. To engrave three plates according to this plan, which may print each of the colours exactly in the places where, and proportion in which, they are wanted. 3. To find three transparent substances proper for printing with these three primitive colours. The manner in which M. le Blon prepared the plates was as follows: The three plates of copper were first well fitted with respect to size and figure to each other, and grounded in the same manner as those designed for mezzotinto prints: and the exact place and boundary of each of the three primitive colours, conformably to the design, were sketched out on three papers, answering in dimensions to the plate. These sketches were then chalked on the plates; and all the parts of each plate that were not to convey the colour to which it was appropriated to the print, were entirely scraped away, as in forming the light of mezzotinto prints. The parts that were to convey the colours were then worked upon; and where the most light or diluted teints of the colour were to be, the grain in the ground was proportionably taken off; but where the full

Mezzotinto || Micah.

full colour was required, it was left entire. In this regard was had, not only to the effects of the colour in its simple state, but to its combined operation, either in producing orange-colour, green, or purple, by its admixture with one alone; and likewise to its forming brown, gray, and shades of different degrees, by its co-operation with both the others. But though the greatest part of the engraving was performed in the mezzotinto manner, yet the graver was employed occasionally for strengthening the shades, and for correcting the outline where it required great accuracy and steadiness. It was found necessary sometimes to have two separate plates for printing the same colour, in order to produce a stronger effect: but the second plate, which was used to print upon the first, was intended only to glaze and soften the colours in particular parts that might require it. With respect to the black and brown teints, which could not be so conveniently produced in a due degree by the mixture of the colours, umber and black were likewise used.

With respect to the order in which the plates are to be applied, it may be proper to observe, that the colour which is least apparent in the picture should be laid on first; that which is betwixt the most and least apparent next; and that which predominates last; except where there may be occasion for two plates for the same colour, as was before mentioned; or where there is any required for adding browns and shades.

M. le Blon applied this art to portraits, and showed, by the specimens he produced, the possibility of its being brought, by farther improvements, to afford imitations of painting which might have some value. It is nevertheless much better adapted to the simpler subjects, where there are fewer intermixtures of colours; and where the accuracy of the reflections, and demi-teints, are not so essentially necessary to the truth of the design, from the greater latitude of form, and disposition of the colour, as in plants, anatomical figures, and some subjects of architecture. But perhaps plates engraved or rather finished with the tool, particularly with respect to the outline, would be better accommodated in some of these cases than those prepared only by scraping.

M. Cochin remarks at the end of an account he has given of M. le Blon's manner, that though this ingenious artist confined his method principally to the use of three colours; yet, should this invention be again taken up and cultivated, there would be more probability of success in using a greater variety; and that several different kinds might be printed by one plate, provided they were laid on in their respectively proper places by printing-balls, which should be used for that colour only. His hint might however be very greatly improved, by the further assistance of pencils, accommodated to the plates, for laying on the colours in the proper parts.—For the method of taking off mezzotinto prints on glass, see *Back-painting*.

MIASMA, among physicians, a particular kind of effluvia, by which certain fevers, particularly intermittents, are produced.

MICA, *Muscovy glass*, or *Glimmer*, a species of mineral substance. See Mineralogy *Index*.

MICAH, or *The Book of Micah*, a canonical book of the Old Testament, written by the prophet Micah, who is the sixth of the twelve lesser prophets. He is cited by Jeremiah, and prophesied in the days of Jotham, Ahaz, and Hezekiah. He censures the reigning vices of Jerusalem and Samaria, and denounces the judgments of God against both kingdoms. He likewise foretels the confusion of the enemies of the Jews, the coming of the Messiah, and the glorious success of his church.

Micah, Michael.

MICHAEL, or Michel, (i. e. *who is like to God?*) The scripture account of Michael is, that he was an archangel, who presided over the Jewish nation, as other angels did over the Gentile world, as is evident of the kingdoms of Persia and Greece, (Dan. x. 13.): that he had an army of angels under his command (Rev. xii. 7.); that he fought with the Dragon, or Satan and his angels; and that, contending with the Devil, he disputed about the body of Moses, (Jude 9.). As to the combat between Michael and the Dragon, some authors understand it literally, and think it means the expulsion of certain rebellious angels, with their head or leader, from the presence of God. Others take it in a figurative sense; and refer it, either to the contest that happened at Rome between St Peter and Simon Magus, in which the apostle prevailed over the magician, or to those violent persecutions under which the church laboured for three hundred years, and which happily ceased when the powers of the world became Christian. Among the commentators who maintain the former opinion is Grotius; and among those who take it in a figurative sense are Hammond and Mede.

The contest about the body of Moses is likewise taken both literally and figuratively. Those who understand it literally are of opinion, that Michael by the order of God hid the body of Moses after his death; and that the Devil endeavoured to discover it, as a fit means to entice the people to idolatry, by a superstitious worship of his relics. But this dispute is figuratively understood to be a controversy about rebuilding the temple, and restoring the service of God among the Jews at Jerusalem; the Jewish church being fitly enough styled the body of Moses. It is thought by some, that this story of the contest between Michael and the Devil was taken by St Jude out of an apocryphal book called *The Assumption of Moses*.

The Romish church celebrates three appearances of Michael, of which no mention is made in scripture, and which have happened, they say, a long time after the age of the apostles. The first appearance of this archangel was at Colossæ in Phrygia, but at what time is uncertain. The second is that of Mount Garganus, in the kingdom of Naples, about the end of the fifth century. The third is his appearance to Aubert bishop of Avranches, upon a rock called the *Tomb*, where at this day is the abbey of St Michael. This was about the year 706. The first of these festivals is observed on the 6th of September, the second on the 6th of May, and the last on the 16th of October. It has been supposed, that it was Michael the archangel who conducted the Israelites in their journey through the wilderness, (see Exod. xxxii. 20, 23, and xxxiii. 2.); that it was he who appeared to Moses in the burning bush; who appeared to Joshua in the fields of Jericho, and to Gideon and Manoah the father of Samson;

and,

Michael.

and, in a word, to him have been imputed the greatest part of the most remarkable appearances either in the Old or New Testament.

Michael Angelo. See Angelo.

Mount Michael, formerly one of the most celebrated state prisons of France, lies about 20 miles from Granville. It is a rock situated in the middle of the bay of Avranches; and is only accessible at low water. Nature has completely fortified one side, by its craggy and almost perpendicular descent, which renders it impracticable to mount it by any address or courage, however consummate. The other parts are surrounded by walls fenced with semilunar towers after the Gothic manner; but sufficiently strong, together with the advantage of its situation, to render it impregnable to any attack. At the foot of the mountain begins a street or town, which winds round its base to a considerable height. Above are chambers where state prisoners are kept, and where there are other buildings intended for residence. On the summit is erected the abbey itself, occupying a prodigious space of ground, and of a strength and solidity equal to its enormous size; since it has for many centuries withstood all the injuries of the weather, to which it is so much exposed. In an apartment, called the *Sale de Chavalerie*, the knights of St Michael used to meet in solemn convocation on important occasions. They were the defenders and guardians of this mountain and abbey, as those of the Temple, and of St John of Jerusalem, were of the holy sepulchre. The hall in which they met is very spacious, but rude and barbarous. At one end is a painting of the archangel, the patron of their order; and in this hall Louis XI. first instituted and invested with the insignia of knighthood the chevaliers of the cross of St Michael. There is a miserable dark apartment, or rather dungeon, in which many eminent persons were formerly confined. In the middle of it is a cage, composed of prodigious bars of wood; and the wicket which gives entrance into it is 10 or 12 inches in thickness. The inside of it comprises about 12 or 14 feet square, and it is nearly 20 in height. Towards the latter end of the 17th century, a newswriter in Holland, who had presumed to print some very severe and sarcastic reflections on Madame de Maintenon, was confined in this place. Some months after his publication, he was induced, by a person sent expressly for that purpose, to make a tour into French Flanders. The moment he had quitted the Dutch territories, he was put under arrest; and immediately, by his majesty's express command, conducted to Mount Michael, where he was shut up in this cage. Here he lived upwards of 23 years; and here he at length expired. During the long nights of winter, no candle or fire was allowed him. He was not permitted to have any book. He saw no human face, except the gaoler, who came once every day to present him, through a hole in the wicket, with his little portion of bread and wine. No instrument was given him with which he could destroy himself: but he found means at length to draw out a nail from the wood, with which he engraved, or cut on the bars of his cage, certain fleurs de lis and armorial bearings, which formed his only employment and recreation. They are very curiously performed considering the rudeness of his instrument.

The subterraneous chambers in this mountain are said to be so numerous, that the gaolers themselves do not know them. There are certain dungeons called *aubliettes*, into which they were accustomed anciently to let down malefactors guilty of very heinous crimes: they provided them with a loaf of bread and a bottle of wine, and then they were totally forgotten, and left to perish by hunger in the dark vaults of the rock. This punishment, however, has not been inflicted by any king in the last or present century.

Here also is a remarkable chamber, in one corner of which is a kind of window: between this and the wall of the building is a very deep space, of near 100 feet perpendicular, at the bottom of which is another window opening to the sea. It is called the *Hole of Montgomeri*; and the history of it is as follows: In the year 1559, Henry II. king of France was unfortunately killed at a tournament by the count de Montgomeri *. He was a Huguenot; and having escaped the massacre of Paris, made head against the royal forces in Normandy, supported by Queen Elizabeth with arms and money. Being driven from his fortresses in these parts, he retired to a rock called the *Tombelaine*: This is another similar to Mount Michael; only three quarters of a league from it, and of nearly equal dimensions. At that time there was a castle upon it, which has since been demolished, and of which scarce any vestiges now remain. From this fortress, accessible only at low-water, he continually made excursions, and annoyed the enemy, who never dared to attack him. He coined money, laid all the adjacent country under contribution, and rendered himself universally dreaded. Desirous, however, to surprise Mount Michael, he found means to engage one of the monks resident in the abbey; who promised to give him the signal for his enterprise by displaying a handkerchief. The monk having made the signal, betrayed him, and armed all his associates, who waited Montgomeri's arrival. The chieftan came, attended by 50 chosen soldiers, all desperate, and capable of any attempt. They crossed the sand; and having placed their sealing-ladders, mounted one by one. As they came to the top, they were despatched, each in turn, without noise. Montgomeri, who followed last, discovered the perfidy, and escaped with only two of his men, with whom he regained the Tombelaine. They preserve with great care the ladders and grappling irons used on this occasion. The count was at last besieged and taken prisoner, by the mareschal de Matignon, in 1574, at Domfront, in Normandy; and Catharine de Medicis, who hated him for having been, though innocently, the cause of her husband's death, caused him to be immediately executed.

* See *France*, N° 140.

The church of Mount Michael is a great curiosity. It stands on nine pillars of most enormous dimensions, built on the solid rock. Each of them appears to be about 25 feet in circumference: besides these, there are two others much inferior in size, on which the centre of the church rests, and over which is the tower. The following is the legendary account of the origin of this church: In the reign of Childibert II. there was a bishop of Avranches named *St Aubert*. To this holy man the archangel Michael was pleased to appear one night, and ordered him to go to this rock to build a church. St Aubert treated this as a dream; upon which the angel appeared a second time; and being still disobeyed,

disobeyed, he returned a third time, when, by way of imprinting his command upon the saint's memory, he made a hole in his skull by touching it with his thumb. The skull is still preserved in the treasury of the church. It is enclosed in a little shrine of gold, and a crystal, which opens over the orifice, admits the gratification of curiosity by the minutest examination of it. The hole is of a size and shape proportionable to the thumb said to have produced it; but it is impossible to determine whether it has been really made by a knife or any other way. It is not to be supposed that the saint would forget such a sensible mark of the angel's displeasure; he therefore immediately repaired to the rock, and constructed a small church, as he had been commanded. Here, however, true history supplies the place of fable; and informs us, that it was in 966 when Richard the second duke of Normandy began to build the abbey. It was completed about the year 1070, under William the Conqueror, though many other additions were made by succeeding abbots.

In the treasury of the church are innumerable other relics: among which some few have a real and intrinsic value. There is a fine head of Charles VI. of France, cut in a crystal, and the representation of a cockle-shell in gold, weighing many pounds, given by Richard II. duke of Normandy, when he founded the abbey. There is an arm said to belong to *St Richard* king of England; but who this saint was it must be very difficult to determine. Such is the history of the prison, abbey, and church of Mount Michael previous to the revolution; they have probably undergone some changes since that period.

St MICHAEL'S, a borough town of Cornwall, between St Columb and Truro, 247 miles from London. Though one of the oldest boroughs in the county by prescription, and of great note in the Saxon times, it is a mean hamlet in the parishes of Newland and St Enidore; yet it is governed by a portreeve, chosen yearly by a jury of the chief inhabitants, out of the six chief tenants, called deputy lords of the manor, because they hold lands in the borough. Here is no market, but two fairs. A court-leet is held here twice a-year. This place was formerly called Modishole, and afterwards Michael. Its list of members begins in the 6th of Edward VI.

St Michael's Mount, in the county of Cornwall, in the corner of Mount's Bay, is a very high rock, only divided by the tide from the main land, so that it is land and island twice a-day. The town here was burnt by the French in the reign of King Henry VIII. At the bottom of this mount, in digging for tin, there have been found spear heads, battle axes, and swords, of brass, all wrapt up in linen. The county is contracted here into a sort of isthmus, so that it is scarcely four miles between the Channel and the Severn sea.—Large trees have been driven in by the sea between this mount and Penzance.

MICHAELIS, John David, a celebrated biblical critic, and author of many esteemed works, was the eldest son of Dr Christian Benedict Michaelis, professor in the university of Halle in Lower Saxony, and was born at that place, Feb. 27. 1717. His father devoted him at an early age to an academical life; and with that view he received the first part of his education in a celebrated Prussian seminary, called the *Orphan house*, at Glanche, in the neighbourhood of his native place. He commenced his academical career at Halle in 1733, and took his master's degree in the faculty of philosophy in 1739. In 1741 he made an excursion to this country, where his superior knowledge of the oriental languages, which was considerably increased by his indefatigable researches in the Bodleian library at Oxford, introduced him to the acquaintance, and gained him the esteem, of our first literary characters; with several of whom, and particularly Bishop Lowth, he was in correspondence for many years. On his return to Halle, after an absence of fifteen months, he began to read lectures on the historical books of the Old Testament, which he continued after his removal to Gottingen in 1745. In 1746 he was appointed professor extraordinary, and soon after professor of philosophy, in that university. The next year he obtained a place of secretary to the Royal Society there, of which he was director in 1761, and was soon afterwards made aulic counsellor by the court of Hanover. In 1764 his distinguished talents, but chiefly a publication relative to a journey to Arabia, which was undertaken by several literary men, at the expence of the king of Denmark, in consequence of his application by means of Count Bernsdorf, procured him the honour of being chosen a correspondent, and afterwards foreign member of the Academy of Inscriptions at Paris, of whom the institution admitted only eight; and in the same year he became a member of the society of Haerlem. In 1775, Count Hopkin, who eighteen years before had prohibited the use of his writings at Upsal, when he was chancellor of that university, prevailed on the king of Sweden to confer on him the order of the Polar Star, as a national compensation. In 1786 he was raised to the distinguished rank of privy counsellor of justice by the court of Hanover; and in 1788 received his last literary honour, by being unanimously elected a fellow of the Royal Society of London.—His great critical knowledge of the Hebrew language, which he displayed in a new translation of the Bible, and in other works, raised him to a degree of eminence almost unknown before in Germany; and his indefatigable labours were only equalled by his desire of communicating the knowledge he acquired to the numerous students of all countries who frequented his admirable lectures, which he continued to deliver on various parts of the sacred writings in half-yearly courses, and on the Hebrew, Arabic, and Syriac languages, to the last year of his life. He was professor in the university of Gottingen 45 years, and, during that long period, he filled the chair with dignity, credit, and usefulness. He died October 22. 1791, aged 74. He is said to have left behind him several valuable MSS. Of the works that were published during his life-time, and which are very numerous, a catalogue, in the order of their publication, is given in the *Gentleman's Magazine* for March 1792.

MICHAELMAS, or *Feast of St Michael and all Angels*, a festival of the Christian church, observed on the 29th of September. See Michael.

MICKLE, William Julius, the celebrated translator of the Lusiad, was the son of the reverend Alexander Mickle a Scotish clergyman, who had formerly been a dissenting minister in London, an assistant to the reverend Dr Watts, and one of the translators of Bayle's Dictionary.

Mickle.

Dictionary. This gentleman having resided a few years in London, was presented to the church of Langholm in Scotland, where he married; and our author was one of the younger sons. He was born about the year 1735, and was educated by his father. In his early years his passion for poetry frequently discovered itself; though till the age of 13 he did not show any particular attachment to books. At that time having accidentally met with Spenser's Faery Queen, he became enamoured of his manner of writing, and instantly began to imitate him. After the death of his father, he came to Edinburgh to reside with his uncle who was a brewer there, and who admitted him into a share of his business; not being qualified to succeed in this line, he went to London about the time of the conclusion of the war which began in 1755, with a view to procure a commission in the marine service. Here he was disappointed; but introduced himself to the first Lord Lyttelton, to whom he sent one of his poems. From his Lordship, however, he received no other favour than being admitted to several interviews, and encouraged to persevere in his poetical plans.

So closely did our author cultivate the study of the muses, that before he was 18 years of age he had written two tragedies and half an epic poem; but all these were committed to the flames. The first of his poems which appeared in print was published in one of the Edinburgh magazines, and entitled, "On passing through the Parliament Close of Edinburgh at Midnight." This was afterwards inserted in A Collection of Original Poems by a Scotch gentleman, vol. ii. p. 137.

From the time of Mr Mickle's arrival in London till the year 1765, it is not known how he employed his time, though it is probable that he was employed in some branch of the printing business; and in 1765 he engaged himself as corrector to the Clarendon press. This year he published the Poem which first brought him into notice, entitled, "Pollio, an Elegiac Ode, written in the Wood near R—— (Roslin) Castle," 4to. This was an elegy written on the death of his brother, which, previous to its publication, had been shown to Lord Lyttelton, and received some corrections from him. The latter, in an epistle to the author, spoke of it as equal to any thing of the kind in our language. In 1767 he published a poem called "The Concubine, in two cantos, after the manner of Spencer," 4to; and in 1769 he published, "A Letter to Mr Harwood, wherein some of his evasive glosses, false translations, and blundering criticisms, in support of the Arian Heresy, contained in his literal translation of the New Testament, are pointed out and confuted," 8vo: and next year he published "Mary Queen of Scots, an Elegy;" "Hengist and Mary, a ballad;" and "Knowledge, an Ode;" in Pearch's Collection of Poems. In 1770 he published "Voltaire in the Shades, or Dialogues on the Deistical Controversy," 8vo. The Elegy on Mary had been submitted to the judgment of Lord Lyttelton, who declined to criticise it, not for its deficiency in poetical merit, but from thinking differently from the author concerning that unfortunate princess.

About this time Mr Mickle was a frequent writer in the Whitehall Evening Post; but a more important work now engaged his attention. When no more than 17 years of age he had read Castara's translation of the Lusiad of Camoens into French, and then projected the design of giving an English translation of it. From this, however, he was prevented by various avocations till the year 1771, when he published the first book as a specimen: and having prepared himself by acquiring some knowledge of the Portuguese language, he determined to apply himself entirely to this work. With this view he quitted his residence at Oxford, and went to a farm house at Forest-hill, where he pursued his design with unremitting assiduity till the year 1775, when the work was entirely finished.

During the time that Mr Mickle was engaged in this work, he subsisted entirely by his employment as corrector of the press; and on his quitting that employment he had only the subscriptions he received for his translation to support him. Notwithstanding these difficulties, he adhered steadily to the plan he laid down, and completed it in about five years.

When his work was finished, Mr Mickle applied to a person of great rank, with whom his family had been connected, for permission to dedicate it to him. Permission was granted, and his patron honoured him with a very polite letter; but after receiving a copy, for which an extraordinary price was paid for the binding, he did not think proper to take any notice of the author. At last a gentleman of high rank in the political world, a firm friend to the author, and who afterwards took him under his protection, waited on the patron, and heard him declare that he had not read the work, but that it had been represented not to have the merit it was at first said to possess. The applause with which the work was received, however, soon banished from the author's mind those disagreeable sensations which had been occasioned by the contemptuous neglect of his patron, as well as some severe criticisms which had been circulated concerning it. A second edition was prepared in 1778, with a plate prefixed to it, executed by the celebrated artist Mortimer; on whom Mr Mickle wrote an epitaph in 1779. This year also he published a pamphlet, entitled, "A Candid Examination of the Reasons for depriving the East India Company of its Charter, contained in The History and Management of the East India Company from its Commencement to the Present Time; together with some Strictures on the Self-Contradictions and Historical Errors of Dr Adam Smith, in his Reasons for the Abolition of the said Company," 4to. About this time some of his friends thought of recommending him to the king as deserving of a pension; but this scheme was never put in execution. Dr Lowth, bishop of London, would have put him into orders, and provided for him in the church; but this was not agreeable to our author's disposition. While he was meditating a publication of all his poems, in which he would most probably have found his account, he was appointed secretary to Commodore Johnstone, who had lately obtained the command of the Romney man of war. In November 1779 he arrived at Lisbon, and was named by his patron joint agent for the prizes which were taken. In this capital and its neighbourhood he resided more than six months, being every where received with every mark of politeness and attention;

Mickle || Micrometer.

tention; and during this period he composed his poem called "Almada Hill," which in 1781 was published in quarto. He collected also many particulars concerning the manners of the Portuguese, which he intended also to have published. During his stay at Lisbon the Royal Academy was opened; and Mr Mickle, who was present at the ceremony of its commencement, had the honour to be admitted a member under the presidency of Don John of Braganza, duke of Lafoens. His presence being thought necessary in England to attend to the proceedings of the courts of law respecting the condemnation of some of the prizes, he did not accompany the Commodore in his last expedition, nor did he go any more to sea. In 1782 he published "The Prophecy of Queen Emma, an ancient Ballad lately discovered, written by Johannes Turgottus, prior of Durham, in the reign of William Rufus; to which is added by the Editor, an Account of the Discovery, and Hints towards a Vindication of the Authenticity, of the Poems of Ossian and Rowley," 8vo.

In June this year Mr Mickle married Miss Tomkins, daughter of the person with whom he resided at Forest-hill, while engaged in translating the Lusiad. Having received some fortune with this lady, as well as made some money himself when in the service of Commodore Johnstone, he now enjoyed a comfortable independence. He afterwards fixed his residence at Wheatley in Oxfordshire, and devoted his time to the revision of his poetical works, which he proposed to publish by subscription. During the last seven years of his life he was employed in writing for the European Magazine. The Fragments of Leo, and some of the most approved reviews of books, in that periodical work, were of his production. He died after a short illness, on the 25th of October 1788, at Wheatley, leaving one son behind him. His poetry possesses much beauty, variety, harmony of numbers, and vigour of imagination: his life was without reproach; his foibles were few and inoffensive; his virtues many; and his genius very considerable.

MICROCOSM, a Greek term signifying the *little world;* used by some for *man*, as being supposed an epitome of the universe or great world.

MICROGRAPHY, the description of objects viewed with the assistance of a microscope. See *Microscopic objects*.

MICROMETER, an astronomical instrument, by which small angles, or the apparent magnitudes of objects viewed through telescopes or microscopes are measured with great exactness.

Micrometer first invented by Gascoigne.

1. The first TELESCOPIC micrometers were only mechanical contrivances for measuring the image of an object in the focus of the object-glass. Before these contrivances were thought of, astronomers were accustomed to measure the field of view in each of their telescopes, by observing how much of the moon they could see through it, the semidiameter being reckoned at 15 or 16 minutes; and other distances were estimated by the eye, comparing them with the field of view. Mr Gascoigne, an English gentleman, however, fell upon a much more accurate method before the year 1641, and had a Treatise on Optics prepared for the press; but he was killed during the civil wars in the service of Charles I. and his manuscript was never found. His instrument, however, fell into the hands of Mr R. Townly *, who says, that by the help of it he could mark above 40,000 divisions in a foot.

* Phil. Trans. No 25.

2. Mr Gascoigne's instrument being shown to Dr Hooke, he gave a drawing and description of it, and proposed several improvements†. Mr Gascoigne divided the image of an object in the focus of the object-glass, by the approach of two pieces of metal ground to a very fine edge, in the place of which Dr Hooke would substitute two fine hairs stretched parallel to one another.

† See *Phil. Trans. Abr.* vol. i. p. 217. *Hooke's Posthumous Works*, p. 497, 498; and *Phil. Trans.* vol. xlviii. p. 190.

Huygens's micrometer.

3. Mr Huygens measured the apparent diameters of the planets, by first determining the quantity of the field of view in his telescope; which, he says, is best done by observing the time that a star takes up in passing over it, and then preparing two or three long and slender brass plates, of various breadths, the sides of which are very straight, and converging to a small angle. In using these pieces of brass, he made them slide in two slits, made in the sides of the tube, opposite to the place of the image, and observed in what place it just covered the diameter of any planet, or any small distance that he wanted to measure ‡. It was observed, however, by Sir Isaac Newton, that the diameters of planets, measured in this manner, will be larger than they should be, as all lucid objects appear to be when they are viewed upon dark ones.

‡ *Systema Saturnium*, p. 82.

Marquis of Malvasia's micrometer.

4. In the Ephemerides of the Marquis of Malvasia, published in 1662, it appears that he had a method of measuring small distances between fixed stars and the diameters of the planets, and also of taking accurate draughts of the spots of the moon by a net of silver wire, fixed in the focus of the eye-glass. He likewise contrived to make one of two stars pass along the threads of this net, by turning it, or the telescope, as much as was necessary for that purpose; and he counted, by a pendulum-clock, beating seconds, the time that elapsed in its passage from one wire to another, which gave him the number of minutes and seconds of a degree contained between the intervals of the wires of his net, with respect to the focal length of his telescope.

Auzout's micrometer.

5. In 1666, Messrs Auzout and Picard published a description of a micrometer, which was nearly the same with that of the Marquis of Malvasia, excepting the method of dividing it, which they performed with more exactness by a screw. In some cases they used threads of silk, as being finer than silver wires. Dechales also recommends a micrometer consisting of fine wires, or silken threads, the distances of which were exactly known, disposed in the form of a net, as peculiarly convenient for taking a map of the moon.

De la Hire's micrometer.

6. M. de la Hire says, that there is no method more simple or commodious for observing the digits of an eclipse than a net in the focus of the telescope. These, he says, were generally made of silken threads; and that for this particular purpose six concentric circles had also been made use of, drawn upon oiled paper; but he advises to draw the circles on very thin pieces of glass with the point of a diamond. He also gives several particular directions to assist persons in the use of them.

Common micrometer.

7. *Construction of Different Micrometers.* The first we shall describe is the common micrometer. Let ABCD be a section of the telescope at the principal focus of the object-glass

Micrometer. Plate CCCXXXV. Fig. 1. object-glass, or where the wires are situated, which are placed in a short tube containing the eye-glass, and may be turned into any position by turning that tube; $m n$ is a fine wire extended over its centre; vw, xy, are two parallel wires well defined, and perpendicular to mn; vw is fixed, and xy moves parallel to it by means of a screw, which carries two indexes over a graduated plate, to show the number of revolutions and parts of a revolution which it makes. Now to measure any angle, we must first ascertain the number of revolutions and parts of a revolution corresponding to some known angle, which may be thus done: 1st, Bring the inner edges of the wires exactly to coincide, and set each index to 0; turn the screw, and separate the wires to any distance; and observe the time a star m is in passing along the wire $m n$ from one vertical wire to the other: for that time, turned into minutes and seconds of a degree, will be the angle answering to the number of revolutions, or the angle corresponding to the distance. Thus, if d=cos. of the star's declination, we have $15' \, dm$, the angle corresponding to this distance; and hence, by proportion, we find the angle answering to any other. 2*dly*, Set up an object of a known diameter, or two objects at a given distance, and turn the screw till the vertical wires become tangents to the object, or till their opening just takes in the distance of the two objects upon the wire mn; then from the diameter, or distance of the two objects from each other, and their distance from the glass, calculate the angle, and observe the number of revolutions and parts corresponding. 3*dly*, Take the diameter of the sun on any day, by making the wires tangents to the opposite limbs, and find, from the nautical almanac, his diameter on that day. Here it will be best to take the upper and lower limbs of the sun when on the meridian, as he has then no motion perpendicular to the horizon. If the edges do not coincide when the indexes stand at 0, we must allow for the error. Instead of making a proportion, it is better to have a table calculated to show the angle corresponding to every revolution and parts of a revolution. But the observer must remember, that when the micrometer is fixed to telescopes of different focal lengths, a new table must be made. The whole system of wires is turned about in its own plane, by turning the eye-tube round with the hand, and by that means the wire $m n$ can be thrown into any position, and consequently angles in any position may be measured. Dr Bradley added a small motion by a rack and pinion to set the wires more accurately in any position.

8. But the micrometer, as now contrived, is of use, not only to find the angular distance of bodies in the field of view at the same time, but also of those which, when the telescope is fixed, pass through the field of view successively; by which means we can find the difference of their right ascensions and declinations.

Fig. 2. Let A a, B b, C c, be three parallel and equidistant wires, the middle one bisecting the field of view; HOR a fixed wire perpendicular to them passing through the centre of the field; and F f, G g, two wires parallel to it, each moveable by a micrometer screw, as before, so that they can be brought up to HOR, or a little beyond. Then to find the angular distance of two objects, bring them very near to B b, and in a line parallel to it, by turning about the wires, and bring one upon HOR, and by the micrometer screw make F f or G g pass through the other; then turn the screw till that wire coincides with HOR, and the arc which the index has passed over shows their angular distance. If the objects be further remote than you can carry the distance of one of the wires F f, G g from HOR, then bring one object to F f and the other to G g; and turn each micrometer screw till they meet, and the sum of the arcs passed over by each index gives their angular distance. If the objects be two stars, and one of them be made to run along HOR, or either of the moveable wires as occasion may require, the motion of the other will be parallel to these wires, and their difference of declinations may be observed with great exactness; but in taking any other distances, the motion of the stars being oblique to them, it is not quite so easy to get them parallel to B b; because if one star be brought near, and the eye be applied to the other to adjust the wires to it, the former star will have gotten a little away from the wire. Dr Bradley, in his account of the use of this micrometer, published by Dr Maskelyne in the Philosophical Transactions for 1772, thinks the best way is to move the eye backwards and forwards as quick as possible; but it seems to be best to fix the eye at some point between, by which means it takes in both at once sufficiently well defined to compare them with B b. In finding the difference of declination, if both bodies do not come into the field of view at the same time, make one run along the wire HOR, as before, and fix the telescope and wait till the other comes in, and then adjust one of the moveable wires to it, and bring it up to HOR, and the index gives the difference of their declinations. The difference of time between the passage of the star at either of the cross moveable wires, and the transit of the other star over the cross fixed wire (which represents a meridian), turned into degrees and minutes, will give the difference of right ascension. The star has been here supposed to be bisected by the wire; but if the wire be a tangent to it, allowance must be made for the breadth of the wire, provided the adjustment be made for the coincidence of the wires. In observing the diameters of the sun, moon, or planets, it may perhaps be most convenient to make use of the outer edges of the wires, because they appear most distinct when quite within the limb: but if there should be any sensible inflection of the rays of light in passing by the wires, it will be best avoided by using the inner edge of one wire and the outward edge of the other; for by that means the inflection at both limbs will be the same way, and therefore there will be no alteration of the relative position of the rays passing by each wire. And it will be convenient in the micrometer to note at what division the index stands when the moveable wire coincides with HOR; for then you need not bring the wire when a star is upon it up to HOR, only reckon from the division at which the index then stands to the above division.

The divided object-glass micrometer hinted at by Mr Savery.

9. With a micrometer thus adapted to a telescope, Mr S. Savery of Exeter proposed a new way of measuring the difference between the greatest and least apparent diameters of the sun, although the whole of the sun was not visible in the field of view at once. The method we shall briefly describe. Place two object-glasses instead

Micrometer. instead of one, so as to form two images whose limbs shall be at a small distance from each other; or instead of two perfect lenses, he proposed to cut a single lens into four parts of equal breadths by parallel lines, and to place the two segments with their straight sides against each other, or the two middle frustums with their opposite edges together; in either case, the two parts which before had a common centre and axis, have now their centres and axes separated, and consequently two images will be formed as before by two perfect lenses. Another method in reflectors was to cut the large concave reflector through the centre, and by a contrivance to turn up the outer edges whilst the straight ones remained fixed; by which means the axis of the two parts became inclined, and formed two images. Two images being formed in this manner, he proposed to measure the distance between the limbs when the diameters of the sun were the greatest and least, the difference of which would be the difference of the diameters required. Thus far we are indebted to Mr Savery for the idea of forming two images; and the admirable uses to which it was afterwards applied we shall next proceed to describe.

Improved by Mr John Dollond. 10. The divided object-glass micrometer, as now made, was contrived by the late Mr John Dollond, and by him adapted to the object-end of a reflecting telescope, and has been since by the present Mr P. Dollond his son applied with equal advantage to the end of an achromatic telescope. The principle is this: The object-glass is divided into two segments in a line drawn through the centre: each segment is fixed in a separate frame of brass, which is moveable, so that the centres of the two segments may be brought together by a handle for that purpose, and thereby form one image of an object; but when separated they will form two images, lying in a line passing through the centre of each segment; and consequently the motion of each image will be parallel to that line, which can be thrown into any position by the contrivance of another handle to turn the glass about in its own plane. The brass-work carries a vernier to measure the distance of the centres of the two segments. Now let E and H be the centres of the two segments, F their principal focus, and PQ two distant objects in FE, FH, produced, or the opposite limbs of the same object PBQD; then the images of P and Q, formed by each segment, or the images of the opposite limbs of the object PBQD, coincide at F: hence two images $m\,z\,$F, $n\,x\,$F of that object are formed, whose limbs are in contact; therefore the angular distance of the points P and Q is the same as the angle which the distance EH subtends at F, which, as the angles supposed to be measured are very small, will vary as EH extremely nearly; and consequently if the angle corresponding to one interval of the centres of the segments be known, the angle corresponding to any other will be found by proportion. Now to find the interval for some one angle, take the horizontal diameter of the sun on any day, by separating the images till the contrary limbs coincide, and read off by the vernier the interval of their centres, and look into the nautical almanac for the diameter of the sun on that day, and you have the corresponding angle. Or if greater exactness be required than from taking the angle in proportion to the distances of their centres, we may proceed thus:—Draw FG perpendicular to EH, which therefore bisects it; then one half EH, or EG, is the tangent of half the angle EFH; hence, half the distance of their centres is to the tangent of half the angle corresponding to that distance as half any other distance of the centres is to the tangent of half the corresponding angle (A).

Fig. 3.

11. From this the method of measuring small angles is manifest; for we consider P, Q either as two objects whose images are brought together by separating the two segments, or as the opposite limbs of one object PBQA, whose images formed by the two segments E, H, touch at F; in the former case, EH gives the angular distance of the two objects; and in the latter, it gives the angle under which the diameter of the object appears. In order to find the angular distance of two objects, therefore, separate the segments till the two images which approach each other coincide; and to find the diameter of an object, separate the segments till the contrary limbs of the images touch each other, and read off the distance of the centres of the segment from the vernier (B), and find the angle as directed in the last article. Hence appears one great superiority in this above the wire micrometer; as, with the one any diameter of an object may be measured with the same ease and accuracy; whereas with the other we cannot with accuracy measure any diameter, except that which is at right angles to the direction of motion.

12. But, besides these two uses to which the instrument

(A) If the object is not distant let f be the principal focus; then Ff : FG :: FG : FK (FG being produced to meet a line joining the apparent places of the two objects P, Q,), ∴ dividendo, fG : FG :: GK : FK, and alternando, fG : GK :: FG : FK :: (by similar triangles) EH : PQ, hence $\frac{\text{EH}}{f\text{G}}=\frac{\text{PQ}}{\text{GK}}$, therefore the angle subtended by EH at $f=$ the angle subtended by PQ at G; and consequently, as fG is constant, the angle measured at G is, in this case, also proportional to EH. The instrument is not adapted to measure the angular distance of bodies, one of which is near and the other at a distance, because their images would not be formed together.

(B) To determine if there be any error in the adjustment of the micrometer scale, measure the diameter of any small well-defined object, as Jupiter's equatoreal diameter, or the longest axis of Saturn's ring, both ways, that is, with 0 on the vernier to the right and left of 0 on the scale, and half the difference is the error required. This error must be added to or subtracted from all observations, according as the diameter measured with 0 on the vernier, when advanced on the scale, is less or greater than the diameter measured the other way. And it is also evident, that half the sum of the diameters thus measured gives the true diameter of the object.

Micrometer. ment seems so well adapted, Dr Maskelyne * has shown, how it may be applied to find the difference of right ascensions and declinations. For this purpose, two wires at right angles to each other, bisecting the field of view, must be placed in the principal focus of the eye-glass, and moveable about in their own plane.—Let HCR *c* be the field of view, HR and C *c* the two wires; turn the wires till the westernmost star, (which is the best, having further to move) run along ROH; then separate the two segments, and turn about the micrometer till the two images of the same star lie in the wire C *c*; and then, partly by separating the segments, and partly by raising or depressing the telescope, bring the two innermost images of the two stars to appear and run along ROH, as *a*, *b*, and the vernier will give the difference of their declinations; because, as the two images of one of the stars coincided with C *c*, the image of each star was brought perpendicularly upon HR, or to HR in their proper meridian. And, for the same reason, the difference of their times of passing the wire CO *c* will give their difference of right ascensions. These operations will be facilitated, if the telescope be mounted on a polar axis. If two other wires KL, MN, parallel to C *c*, be placed near H and R, the observation may be made on two stars whose difference of meridians is nearly equal to HR the diameter of the field of view, by bringing the two images of one of the stars to coincide with one of these wires. If two stars be observed whose difference of declinations is well settled, the scale of the micrometer will be known.

* *Phil. Trans.* 1771.

Fig. 4.

13. It has hitherto been supposed, that the images of the two stars can be both brought into the field of view at once upon the wire HOR: but if they cannot, set the micrometer to the difference of their declinations as nearly as you can, and make the image which comes first run along the wire HOR, by elevating or depressing the telescope; and when the other star comes in, if it do not also run along HOR, alter the micrometer till it does, and half the sum of the numbers shown by the micrometer at the two separate observations of the two stars on the wire HOR will be the difference of their declinations. That this should be true, it is manifestly necessary that the two segments should recede equally in opposite directions; and this is effected by Mr Dollond in his new improvement of the object-glass micrometer.

14. The difference of right ascensions and declinations of Venus or Mercury in the sun's disk and the sun's limb may be thus found. Turn the wires so that the north limb *n* of the sun's image AB, or the north limb of the image V of the planet, may run along the wire RH, which therefore will then be parallel to the equator, and consequently C *c* a secondary to it; then separate the segments, and turn about the micrometer till the two images V *v* of the planet pass C *c* at the same time, and then by separating the segments, bring the north limb of the northernmost image V of the planet to touch HR, at the time the northernmost limb *n* of the southernmost image AB of the sun touches it, and the micrometer shows the difference of declinations of the northernmost limbs of the planet and sun, for the reason formerly given (Art. 11.) we having brought the northernmost limbs of the two innermost images V and AB to HR, these two being manifestly interior to *v* and the northernmost limb N of the image PQ. In the same manner we take the difference of declinations of their southernmost limbs; and half the difference of the two measures (taking immediately one after another) is equal to the difference of the declinations of their centres, without any regard to the sun's or planet's diameters, or error of adjustment of the micrometer; for as it affects both equally, the difference is the same as if there were no error: and the difference of the times of the transits of the eastern or western limbs of the sun and planet over C *c* gives the difference of their right ascensions.

Fig. 5.

15. Instead of the difference of right ascensions, the distance of the planet from the sun's limb, in lines parallel to the equator, may be more accurately observed thus: Separate the segments, and turn about the wires and micrometer, so as to make both images V, *v*, run along HR, or so that the two intersections I, T of the sun's image may pass C *c* at the same time. Then bring the planet's and sun's limbs into contact, as at V, and do the same for the other limb of the sun, and half the difference gives the distance of the centre of the planet from the middle of the chord on the sun's disk parallel to the equator, or the difference of the right ascensions of their centres, allowing for the motion of the planet in the interval of the observations, without any regard to the error of adjustment, for the same reason as before. For if you take any point in the chord of a circle, half the difference of the two segments is manifestly the distance of the point from the middle of the chord; and as the planet runs along HR, the chord is parallel to the equator.

Fig. 6.

In like manner, the distances of their limbs may be measured in lines perpendicular to the equator, by bringing the micrometer into the position already described, (Art. 13.), and instead of bringing V to HR, separate the segments till the northernmost limbs coincide as at V; and in the same manner make their southernmost images to coincide, and half the difference of the two measures, allowing for the planet's motion, gives the difference of the declinations of their centres.

Fig. 7.

Hence the true place of a planet in the sun's disc may at any time of its transit be found; and consequently the nearest approach to the centre and the time of ecliptic conjunction may be deduced, although the middle should not be observed.

16. But however valuable the object-glass micrometer undoubtedly is, difficulties sometimes have been found in its use, owing to the alteration of the focus of the eye, which will cause it to give different measures of the same angle at different times. For instance, in measuring the sun's diameter, the axis of the pencil coming through the two segments from the contrary limbs of the sun, as PF, QF, fig. 3. crossing one another in the focus F under an angle equal to the sun's semidiameter, the union of the limbs cannot appear perfect, unless the eye be disposed to see objects distinctly at the place where the images were formed; for if the eye be disposed to see objects nearer to or further off than that place, in the latter case the limbs will

Disadvantage of the object-glass micrometer.

Micrometer.

will appear separated, and in the former they will appear to lap over (c). This imperfection led Dr Maskelyne to inquire, whether some method might not be found of producing two distinct images of the sun, or any other object, by bringing the axis of each pencil to coincide, or very nearly so, before the formation of the images, by which means the limbs when brought together would not be liable to appear separated from any alteration of the eye; and this he found would be effected by the refraction of two prisms, placed either without or within the telescope; and on this principle, placing the prisms within, he constructed a new micrometer, and had one executed by Mr Dollond, which upon trial answered as he expected. The construction is as follows.

Dr Maskelyne's prismatic micrometer. Fig. 8, 9.

17. Let AB be the object-glass; *a b* the image, suppose of the sun, which would have been formed in the principal focus Q; but let the prisms PR, SR be placed to intercept the rays, and let EF, WG, be two rays proceeding from the eastern and western limbs of the sun, converging, after refraction at the lens, to *a* and *b*; and suppose the refraction of the prisms to be such, that in fig. 8. the ray EFR, after refraction at R by the prism PR, may proceed in the direction RQ; and as all the rays which were proceeding to *a* suffer the same refraction at the prism, they will all be refracted to Q; and therefore, instead of an image *a b*, which would have been formed by the lens alone, an image Q *c* is formed by those rays which fall on the prism PR; and for the same reason, the rays falling on the prism SR will form an image Q *d*: and in fig. 9. the image of the point *b* is brought to Q, by the prism PR, and consequently an image Q *d* is formed by those rays which fall on PR: and for the same reason, an image Q *c* is formed by the rays falling on SR. Now in both cases, as the rays EFR, WGR, coming from the two opposite limbs of the sun, and forming the point of contact of the two limbs, proceed in the same direction RQ, they must thus accompany each other through the eye-glass and also through the eye, whatever refractive power it has, and therefore to every eye the images must appear to touch. Now the angle *a* R *b* is twice the refraction of the prism, and the angle *a* C *b* is the diameter of the sun; and as these angles are very small, and have the same subtense *a b*, we have the angle *a* R *b* : angle *a* C *b* :: CQ : RQ.—Now as CQ is constant, and also the angle *a* R *b* being twice the refraction of the prism, the angle *a* C *a* varies as RQ. Hence the extent of the scale for measuring angles becomes the focal length of the object-glass, and the angle measured is in proportion to the distance of the prisms from the principal focus of the object-glass; and the micrometer can measure all angles (very small ones excepted, for the reason given in Art. 19.) which do not exceed the sum of the refractions of the prisms; for the angle *a* C *b*, the diameter of the object to be measured, is always *less* than the angle *a* R *b*, the sum of the refractions of the prisms, except when the prisms touch the object-glass, and then they become *equal*. The scale can never be out of adjustment, as the point o, where the measurement begins, answers to the focus of the object-glass, which is a fixed point for all distant objects, and we have only to find the value of the scale answering to some known angle; for instance, bring the two limbs of the sun's images into contact, and measure the distance of the prisms from the focus, and look in the nautical almanac for the sun's diameter, and you get the value of the scale.

Fig. 8.

18. In fig. 8. the limb Q of the image Q *c*, is illuminated by the rays falling on the object-glass between A and F, and of the image Q *d* by those falling between B and G; but in fig. 9. the same limbs are illuminated by the rays falling between B and F, A and G respectively, and therefore will be more illuminated than in the other case; but the difference is not considerable in achromatic telescopes, on account of the great aperture of the object-glass compared with the distance FG.

It might be convenient to have two sets of prisms, one for measuring angles not exceeding 36′, and therefore fit for measuring the diameters of the sun and moon, and the lucid parts and distances of the cusps in their eclipses; and another for measuring angles not much greater than 1′, for the conveniency of measuring the diameters of the planets. For as Q *c* : QR :: sum of the refractions of the prisms : angle *a* C *b*, the apparent diameter of the object, it is evident that if you diminish the third term, you must increase the second in the same ratio, in order to measure the same angle; and thus by diminishing the refractive angle of the prisms, you throw them further from Q, and consequently avoid the inconvenience of bringing them near to Q, for the reason in the next paragraph; and at the same time you will increase the illumination in a small degree. The prisms must be achromatic, each composed of two prisms of flint and crown glass, placed with their refracting angles in contrary directions, otherwise the images will be coloured.

19. In the construction here described, the angle measured becomes evanescent when the prisms come to the principal focus of the object-glass, and therefore o on the scale then begins: but if the prisms be placed in the principal focus they can have no effect, because the pencil of rays at the junction of the prisms would then vanish, and therefore it is not practicable to bring the two images together to get o on the scale. Dr Maskelyne, therefore, thought of placing another pair of prisms within, to refract the rays *before* they came to the other prisms, by which means the two images would be formed into one before they came to the principal focus, and therefore o on the scale could be determined. But to avoid the error arising from the

(c) For if the eye can see distinctly an image at F, the pencils of rays, of which PF, QF are the two axes, diverging from F, are each brought to a focus on the retina at the same point; and therefore the two limbs appear to coincide: but if we increase the refractive power of the eye, then each pencil is brought to a focus, and they cross each other before the rays come to the retina, consequently the two limbs on the retina will lap over; and if we diminish the refractive power of the eye, then each pencil being brought to a focus beyond the retina, and not crossing till after they have passed it, the two limbs on the retina must be separated.

Micrometer.

the multiplication of mediums, he, instead of adding another pair of prisms, divided the object-glass through its centre, and sliding the segments a little it separated the images, and then by the prisms he could form one image very distinctly, and consequently could determine 0 on the scale; for by separating the two segments you form two images, and you will separate the two pencils so that you may move up the two prisms, and the two pencils will fall on each respectively, and the two images may be formed into one. In the instrument which Dr Maskelyne had made, 0 on the scale was chosen to be about $\frac{2}{7}$ of the focal length of the object-glass, and each prism refracted 27′. By this means all angles are measured down to 0.

20. In the Philosophical Transactions for 1779, Mr Ramsden has described two new micrometers, which he contrived with a view of remedying the defects of the object-glass micrometer.

Ramsden's reflecting micrometer.

21. 1. One of these is a *catoptric* micrometer, which, beside the advantage it derives from the principle of reflection, of not being disturbed by the heterogeneity of light, avoids every defect of other micrometers, and can have no aberration, nor any defect arising from the imperfection of materials or of execution; as the extreme simplicity of its construction requires no additional mirrors or glasses to those required for the telescope; and the separation of the images being effected by the inclination of the two specula, and not depending on the focus of any lens or mirror, any alteration in the eye of an observer cannot affect the angle measured. It has peculiar to itself the advantages of an adjustment, to make the images coincide in a direction perpendicular to that of their motion; and also of measuring the diameter of a planet on both sides of the zero, which will appear no inconsiderable advantage to observers who know how much easier it is to ascertain the contact of the external edges of two images than their perfect coincidence.

Fig. 10.

22. A represents the small speculum divided into two equal parts; one of which is fixed on the end of the arm B; the other end of the arm is fixed on a steel axis X, which crosses the end of the telescope C. The other half of the mirror A is fixed on the arm D, which arm at the other end terminates in a socket *y*, that turns on the axis X; both arms are prevented from bending by the braces *a a*. G represents a double screw, having one part *e* cut into double the number of threads in an inch to that of the part *g*: the part *e* having 100 threads in one inch, and the part *g* 50 only. The screw *e* works in a nut F in the side of the telescope, while the part *g* turns in a nut H, which is attached to the arm B; the ends of the arms B and D, to which the mirrors are fixed, are separated from each other by the point of the double screw pressing against the stud *h*, fixed to the arm D, and turning in the nut H on the arm B The two arms B and D are pressed against the direction of the double screw *e g* by a spiral spring within the part *n*, by which means all shake or play in the nut H, on which the measure depends, is entirely prevented.

From the difference of the threads on the screw at *e* and *g*, it is evident, that the progressive motion of the screw through the nut will be half the distance of the separation of the two halves of the mirror; and consequently the half mirrors will be moved equally in contrary directions from the axis of the telescope C.

23. The wheel V fixed on the end of the double screw had its circumference divided into 100 equal parts, and numbered at every fifth division with 5, 10, &c. to 100, and the index I shows the motion of the screw with the wheel round its axis, while the number of revolutions of the screw is shown by the divisions on the same index. The steel screw at R may be turned by the key S, and serves to incline the small mirror at right angles to the direction of its motion. By turning the finger head T, the eye-tube P is brought nearer or farther from the small mirror, to adjust the telescope to distinct vision; and the telescope itself hath a motion round its axis for the conveniency of measuring the diameter of a planet in any direction. The inclination of the diameter measured with the horizon is shown in degrees and minutes by a level and vernier on a graduated circle, at the breech of the telescope.

Fig. 11.

A correction to be applied to the angle.

24. Besides the table for reducing the revolutions and parts of the screw to minutes, seconds, &c. it will require a table for correcting a small error which arises from the excentric motion of the half mirrors. By this motion their centre of curvature will approach a little towards the large mirror: the equation for this purpose in small angles is insensible; but when angles to be measured exceed ten minutes, it should not be neglected. Or, the angle measured may be corrected by diminishing it in the proportion the versed sine of the angle measured, supposing the eccentricity radius, bears to the focal length of the small mirror.

25. Mr Ramsden preferred Cassegrain's construction of the reflecting telescope to either the Gregorian or Newtonian; because in the former, the errors of one speculum are corrected by those of the other. From a property of the reflecting telescope, not generally known, that the apertures of the two specula are to each other very nearly in the proportion of their focal lengths, it follows, that their aberrations will be in the same proportion; and these aberrations will be in the same direction, if the two specula are concave; or in contrary directions if one speculum is concave and the other convex. In the Gregorian telescope, both specula being concave, the aberration at the second image will be the sum of the aberrations of the two mirrors; but in the Cassegrainian telescope, one mirror being concave and the other convex, the aberration at the second image will be the difference between the two aberrations. By assuming such proportions for the *foci* of the specula as are generally used in the reflecting telescope, which is about as 1 to 4, the aberration in the Cassegrainian construction will be to that in the Gregorian as 3 to 5.

Mr Ramsden's eye-glass micrometer.

26. The other is a *dioptric* micrometer, or one suited to the principle of refraction. This micrometer is applied to the erect eye-tube of a refracting telescope, and is placed in the conjugate focus of the first eye-glass: in which position, the image being considerably magnified before it comes to the micrometer, any imperfection in its glass will be magnified only by the remaining eye-glasses, which in any telescope seldom exceeds five or six times. By this position also the size of the micrometer glass will not be the $\frac{1}{100}$ part of the area which would be required if it was placed in the object-glass; and, notwithstanding this great disproportion

Micrometer.

proportion of size, which is of great moment to the practical optician, the same extent of scale is preserved, and the images are uniformly bright in every part of the field of the telescope.

Plate CCCXXXVI.

27. Fig. 12. represents the glasses of a refracting telescope; xy, the principal pencil of rays from the object-glass O; tt and uu, the axis of two oblique pencils; a, the first eye-glass; m, its conjugate focus, or the place of the micrometer; b the second eye-glass; c the third; and d the fourth, or that which is nearest the eye. Let p be the diameter of the object-glass, e the diameter of a pencil at m, and f the diameter of the pencil at the eye; it is evident, that the axis of the pencils from every part of the image will cross each other at the point m; and e, the width of the micrometer-glass, is to p the diameter of the object-glass, as ma is to go, which is the proportion of the magnifying power at the point m; and the error caused by an imperfection in the micrometer-glass placed at m will be to the error, had the micrometer been at O, as m is to p.

Fig. 13.

28. Fig. 13. represents the micrometer; A, a convex or concave lens bisected by a plane across its centre; one of these semi-lenses is fixed in a frame B, and the other in the frame E; which two frames slide on a plate H, and are pressed against it by thin plates $a\,a$: the frames B and E are moved in contrary directions by turning the button D: L is a scale of equal parts on the frame B; it is numbered from each end towards the middle with 10, 20, &c. There are two verniers on the frame E, one at M and the other at N, for the convenience of measuring the diameter of a planet, &c. on both sides the zero. The first division on both these verniers coincides at the same time with the two zeros on the scale, L; and, if the frame is moved towards the right, the relative motion of the two frames is shown on the scale L by the vernier M; but if the frame B be moved towards the left, the relative motion is shown by the vernier N.—This micrometer has a motion round the axis of vision, for the convenience of measuring the diameter of a planet, &c. in any direction, by turning an endless screw F; and the inclination of the diameter measured with the horizon is shown on the circle g by a vernier on the plate V. The telescope may be adjusted to distinct vision by a screw, which moves the whole eye-tube with the micrometer nearer to or farther from the object-glass, as telescopes are generally made; or the same effect may be produced without moving the micrometer, by sliding the part of the eye tube m on the part n, by help of a screw or pinion.

Disadvantages of the common micrometer.

29. Notwithstanding these improvements on micrometers, they are still liable to many sources of error. The imperfections of the wire micrometer, (which was still the most correct instrument for measuring small angles) when employed to determine the distance of close double stars, have been ably pointed out by Dr Herschel.

* *Phil. Trans.* 1782.

30. When two stars are taken between the parallel wires the diameters must be included. Dr Herschel* has in vain attempted to find lines sufficiently thin to extend them across the centres of the stars so that their thickness might be neglected. The threads of the silk-worm, with such lenses as he uses, are so much magnified that their diameter is more than that of many of the stars. Besides, if they were much smaller, the deflection of light would make the attempt to measure the distance of the centres this way fruitless; for he has always found the light of the stars to play upon those lines and separate their apparent diameters into two parts. Now since the spurious diameters of the stars thus included, are continually changing with the state of the air, and the length of time we look at them, we are, in some respect, left at an uncertainty; and our measures taken at different times, and with different degrees of attention, will vary on that account. Nor can we come at the true distance of the centres of any two stars, unless we know the semidiameters of the stars themselves; for different stars have different apparent diameters, which, with a power of 227, may differ from each other as far as two seconds (D).

31. The next imperfection arises from a deflection of light upon the wires when they approach very near to each other; for if this be owing to a power of repulsion lodged at the surface, it is easy to see that such powers must interfere with each other, and give the measures larger in proportion than they would have been if the repulsive power of one wire had not been opposed by a contrary power of the other wire.

32. Another disadvantage of these micrometers is an uncertainty of the real zero. The least alteration in the situation and quantity of light will affect the zero; and a change in the position of the wires will sometimes produce a difference. To remove this difficulty Dr Herschel always found his zero while the apparatus preserved the situation which it had when his observations were made; but this introduces an additional observation.

33. The next imperfection, is that every micrometer hitherto used requires either a screw, or a divided bar and pinion, to measure the distance of the wires or the two images. Those acquainted with works of this kind are sensible how difficult it is to have screws perfectly equal in every thread or revolution of each thread; or pinions and bars that shall be so evenly divided as to be depended upon in every leaf and tooth to the two or three thousandth part of an inch: and yet, on account of the small scale of those micrometers, these quantities are of the greatest consequence; an error of a single thousandth part inducing in most instruments a mistake of several seconds.

34. The greatest imperfection of all is, that the wires require to be illuminated; and when Dr Herschel had double stars to measure, one of which was very obscure, he was obliged to be content with less light than is necessary to make the wires distinct; and several stars on this account could not be measured at all, though not too close for the micrometer.

Dr Herschel, therefore, was led to direct his attention to the improvement of these instruments; and the result of his endeavours has been a very ingenious *lamp-micrometer*, which is not only free from the imperfections above specified, but also possesses the advantages of a large scale.

Dr Herschel's lamp micrometer.

35. It is represented in fig. 14. where ABGCFE is a stand nine feet high, upon which a semicircular board $q\,h\,o\,g\,p$ is moveable upwards or downwards, and is held in its situation by a peg p put into any one of the holes of

(D) These imperfections are remedied in the instrument described in p. 801.

Micrometer. Fig. 1. of the upright piece AB. This board is a segment of a circle of fourteen inches radius, and is about three inches broader than a semicircle, to give room for the handles r D, e P, to work. The use of this board is to carry an arm L, thirty inches long, which is made to move upon a pivot at the centre of the circle, by means of a string, which passes in a groove upon the edge of the semicircle $p\ g\ o\ h\ q$; the string is fastened to a hook at o (not expressed in the figure, being at the back of the arm L), and passing along the groove from $o\ h$ to q is turned over a pulley at q, and goes down to a small barrel c, within the plane of the circular board, where a double-jointed handle e P commands its motion. By this contrivance, we see, the arm L may be lifted up to any altitude from the horizontal position to the perpendicular, or be suffered to descend by its own weight below the horizontal to the reverse perpendicular situation. The weight of the handle P is sufficient to keep the arm in any given position; but if the motion should be too easy, a friction spring applied to the barrel will moderate it at pleasure.

36. In front of the arm L a small slider, about three inches long, is moveable in a rabbet from the end L towards the centre backwards and forwards. A string is fastened to the left side of the little slider, and goes towards L, where it passes round a pulley at m, and returns under the arm from m, n, towards the centre, where it is led in a groove on the edge of the arm, which is of a circular form, upwards to a barrel (raised above the plane of the circular board) at r, to which the handle r D is fastened. A second string is fastened to the slider, at the right side, and goes towards the centre, where it passes over a pulley n; and the weight w, which is suspended by the end of this string, returns the slider towards the centre, when a contrary turn of the handle permits it to act.

37. By a and b are represented two small lamps, two inches high, $1\frac{1}{2}$ in breadth by $1\frac{1}{4}$ in depth. The sides, back, and top, are made so as to permit no light to be seen, and the front consists of a thin brass sliding door. The flame in the lamp a is placed three-tenths of an inch from the left side, three-tenths from the front, and half an inch from the bottom. In the lamp b it is placed at the same height and distance, measuring from the right side. The wick of the flame consists only of a single very thin lamp cotton-thread; for the smallest flame being sufficient, it is easier to keep it burning in so confined a place. In the top of each lamp must be a little slit lengthways, and a small opening in one side near the upper part, to permit the air to circulate to feed the flame. To prevent every reflection of light, the side opening of the lamp a should be to the right, and that of the lamp b to the left. In the sliding door of each lamp is made a small hole with the point of a very fine needle just opposite the place where the wicks are burning, so that when the sliders are shut down, and every thing dark, nothing shall be seen but two fine lucid points of the size of two stars of the third or fourth magnitude. The lamp a is placed so that its lucid point may be in the centre of the circular board where it is fixed. The lamp b is hung to the little slider which moves in the rabbet of the arm, so that its lucid point, in an horizontal position of the arm, may be on a level with the lucid point in the centre. The moveable lamp is suspended upon a piece of brass fastened to the slider by a pin exactly behind the flame, upon which it moves as a pivot. The lamp is balanced at the bottom by a leaden weight, so as to remain upright, when the arm is either lifted above or depressed below the horizontal position. The double-jointed handles r D, e P, consist of deal rods, 10 feet long, and the lowest of them may have divisions, marked upon it near the end P, expressing exactly the distance from the central lucid point in feet, inches, and tenths.

38. Hence we see, that a person at a distance of 10 feet may govern the two lucid points, so as to bring them into any required position south or north preceding or following from 0 to 90° by using the handle P, and also to any distance from six-tenths of an inch to five or six and twenty inches by means of the handle D. If any reflection or appearance of light should be left from the top or sides of the lamps, a temporary screen, consisting of a long piece of pasteboard, or a wire frame covered with black cloth, of the length of the whole arm, and of any required breadth, with a slit of half an inch broad in the middle, may be affixed to the arm by four bent wires projecting an inch or two before the lamps, situated so that the moveable lucid point may pass along the opening left for that purpose.

Fig. 15. Fig. 15. represents part of the arm L, half the real size; S the slider; m the pulley, over which the cord $x\ t\ y\ z$ is returned towards the centre; v the other cord going to the pulley n of fig. 14.; R the brass piece moveable upon the pin c, to keep the lamp upright. At R is a wire rivetted to the brass piece, upon which is held the lamp by a nut and screw. Fig. 16. 17. represent the lamps a, l, with the sliding doors open, to show the situation of the wick. W is the leaden weight with a hole d in it, through which the wire R of fig. 15. is to be passed when the lamp is to be fastened to the slider S. Fig. 18. represents the lamp a with the sliding door shut; l the lucid point; and $i\ k$ the openings at the top, and s at the sides, for the admission of air. Fig. 16. 17. Fig. 18.

39. The motions of this micrometer are capable of great improvement by the application of wheels and pinions, and other mechanical resources; but as the principal object is only to be able to adjust the two lucid points to the required position and distance, and to keep them there for a few minutes, while the observer measures their distance, it will be unnecessary to say more upon the subject.

40. It is well known that we can with one eye look into a telescope, and see an object much magnified, while the other eye may see a scale upon which the magnified picture is thrown. In this manner Dr Herschel generally determined the power of his telescopes; and any one who has been accustomed to make such observations will seldom mistake so much as one in fifty in determining the power of an instrument, and that degree of exactness is fully sufficient for the purpose.

Method of applying the lamp micrometer.

41. When Dr Herschel uses this instrument he puts it at ten feet distance from the left eye, in a line perpendicular to the tube of his Newtonian telescope, and raises the moveable board to such a height that the lucid point of the central lamp may be upon a level with the eye. The handles, lifted up, are passed through two loops fastened to the tube, just by the observer, so as to be ready for his use. The end of tube is cut away, so

Micrometer.

so as to leave the left eye entirely free to see the whole micrometer.

42. The telescope being directed to a double star, it is viewed with the right eye, and at the same time with the left it is seen projected upon the micrometer; then, by the handle P, the arm is raised or depressed so as to bring the two lucid points to a similar situation with the two stars; and, by the handle D, the moveable lucid point is brought to the same distance of the two stars, so that the two lucid points may be exactly covered by the stars.

43. With a rule, divided into inches and fortieth parts, the distance of the lucid points is thus determined with the greatest accuracy; and the measure thus obtained is the tangent of the magnified angle under which the stars are seen to a radius of ten feet; therefore, the angle being found and divided by the power of the telescope, the real angular distance of the centres of a double star is ascertained. On September 25. 1781, Dr Herschel measured α Herculis with this instrument. Having caused the two lucid points to coincide with the stars, he found the radius or distance of the central lamp from the eye 10 feet 4.15 inches; the tangent or distance of the two lucid points 50.6 fortieth parts of an inch; this gives the magnified angle 35′, and dividing by the power 460, we obtain 4″ 34‴ for the distance of the centres of the two stars. The scale of the micrometer at this convenient distance, with the power of 460, is above a quarter of an inch to a second; and by putting on a power of 932, we obtain a scale of more than half an inch to a second, without increasing the distance of the micrometer; whereas the most perfect micrometers, with the same instrument, had a scale of less than the two thousandth part of an inch to a second.

Mr Brewster's micrometer.

44. Mr Brewster has lately directed his attention to the improvement of micrometers, and has invented one in particular which appears to be highly deserving of notice in this place. In this instrument a pair of *fixed* wires is made to subtend different angles by varying the magnifying power of the telescope, by sliding one tube within another; whereas in all other micrometers with wires this effect is produced by mechanical contrivances. Mr Brewster's method of shutting and opening the wires optically is therefore free from all those sources of error to which other micrometers are subject, and renders it particularly useful to the practical astronomer; while the mode of changing the magnifying power by the motion of a second object-glass affords a length of scale equal to the local distance of the principal object-glass. The same principle is peculiarly applicable to the Gregorian telescope; for the magnifying power of this instrument can be changed by merely increasing or diminishing the distance of the eye-piece from the large speculum.

45. In the common micrometer, which can manifestly, as well as Mr Cavallo's and Mr Brewster's, be used in the mensuration of distances, the focal length of the telescope to which it is attached remains always the same; so that a correction computed from an optical theorem must be applied to every angle that is measured: but in Mr Brewster's telescope and micrometer, the focal length varies in the same proportion as the distance of the object; and consequently no correction of the angles can be necessary. To obviate the necessity of having a stand for the instrument, which would prevent its usefulness at sea, Mr Brewster divides the second or moveable object-glass into two, as in the divided object-glass micrometer. By this contrivance two images are formed, and these images are separated or made to form different angles at the eye, by bringing the moveable object-glass nearer to the fixed one. In determining the angle, therefore, we have only to bring the two images of the object into contact; and such contact the eye is capable of ascertaining even during the agitation of a carriage, as the two images retain the same relative position whatever be their absolute motion.

This ingenious instrument, being formed with sliding tubes, is very portable and convenient; and will be found extremely useful to medical gentlemen, and others who may wish to ascertain distances without a more cumbersome apparatus. *Haüy's Nat. Phil. by Gregory*, vol. ii. p. 427.

46. Mr Brewster, we understand, still continues to direct his attention to the subject of micrometers, keeping in view the improvement of these instruments, not only in greater accuracy of construction, but also in their more extensive application to various practical purposes. An account of those uses and improvements is to form the subject of an appropriate publication; and, if we are rightly informed, the author deems them of sufficient importance to secure to himself, by patent, the exclusive right to the advantages which he thinks will arise from using them.

Cavallo's mother-of-pearl micrometer.

47. A very simple micrometer for measuring small angles with the telescope has been invented by Mr Cavallo*. It consists of a thin and narrow slip of mother-of-pearl finely divided, and situated in the focus of the eye-glass of a telescope, just where the image of the object is formed. It is immaterial whether the telescope be a refractor or a reflector, provided the eye-glass be a convex lens.

* *Philos. Trans.* 1771, p. 283.

The simplest way of fixing it is to stick it upon the diaphragm, which generally stands within the tube, in the focus of the eye-glass. When thus fixed, the divisions of the micrometrical scale will appear very distinct, unless the diaphragm is not exactly in the focus; in which case, the scale must be placed accurately in the focus of the eye-glass, either by moving the diaphragm, or by interposing any thin substance, such as paper or card between it and the scale. This construction is fully sufficient, when the telescope is always to be used by the same person; but when different persons are to use it, then the diaphragm which supports the micrometer must be constructed so as to be easily moved backwards or forwards, though that motion need not be greater than about $\frac{1}{8}$ or $\frac{1}{10}$ of an inch.

Fig. 19.

The scale of the micrometer is represented in fig. 19. which is about four times greater than one which Mr Cavallo has adapted to a three-feet achromatic telescope that magnifies about 84 times. It is something less than the 24th part of an inch broad; its thickness is equal to that of common writing paper; and the length of it is determined by the breadth of the field of view. The divisions are 200ths of an inch, and the lines which form them reach from one edge of the scale to about the middle of it, excepting every fifth and tenth division, which are longer. Two divisions of the scale in the telescope already mentioned are very nearly equal to one minute; and as a quarter of one of those divisions may be easily distinguished by the eye, an angle of one-eighth part of a minute, or of $7''\frac{1}{2}$, may be measured with it.

In

Micrometer.

In looking through a telescope furnished with such a micrometer, the field of view appears divided by the micrometer scale, the breadth of which occupies about $\frac{1}{7}$th of the aperture; and as the scale is semitransparent, that part of the object which is behind it may be discerned sufficiently well to ascertain the division, with which its borders coincide. Fig. 20. shows the appearance of the field of the telescope with the micrometer, when directed to the title page of the Philosophical Transactions, in which it appears that the thickness of the letter C is equal to three-fourths of a division, the diameter of the O is equal to three divisions, and so on.

Fig. 20.

48. After having adapted this micrometer to the telescope, we must then ascertain the value of the divisions. It is hardly necessary to mention in this place, that though those divisions measure the chords of the angles, and not the angles or arches themselves, and the chords are not as the arches, yet in small angles the chords, arches, sines, and tangents, follow the same proportion so very nearly, that the difference may be safely neglected: so that if one division of this micrometer is equal to one minute, we may conclude that two divisions are equal to two minutes, three divisions to three minutes, and so on. In order to ascertain the value of the divisions of this micrometer, the following simple and accurate method may be adopted,

Mark upon a wall the length of six inches, by making two dots or lines six inches asunder, or by fixing a six-inch ruler upon a stand; then place the telescope before it so that the ruler or six-inch length may be at right angles with the direction of the telescope, and just 57 feet $3\frac{1}{2}$ inches distant from the object-glass of the telescope: this done, look through the telescope at the ruler or other extension of six inches, and observe how many divisions of the micrometer are equal to it, and that same number of divisions is equal to half a degree, or 30′, as it may be shewn by plane trigonometry.

49. When this value has been once ascertained, any other angle measured by any other number of divisions is determined by simple proportion. Thus, if the diameter of the sun seen through the same telescope, be equal to 12 divisions, say as $11\frac{1}{2}$ divisions are to 30 minutes, so are 12 divisions to $\left(\frac{12' \times 30'}{11.5}\right)$ 31′.3, which is the required diameter of the sun.

Notwithstanding the facility of this calculation, a scale may be made answering to the divisions of a micrometer, which will show the angle corresponding to any number of divisions by mere inspection. Thus, for the above-mentioned small telescope, the scale is represented in fig. 21. AB is a line drawn at pleasure; it is then divided into 23 equal parts, and those divisions which represent the divisions of the micrometer that are equal to one degree, are marked on one side of it. The line is then divided again into 60 equal parts, which are marked on the other side of it; and these divisions represent the minutes which correspond to the divisions of the micrometer: thus the figure shows, that six divisions of the micrometer are equal to $15\frac{1}{2}$ minutes, $11\frac{1}{4}$ divisions are nearly equal to 29 minutes, &c. What has been said of minutes may be said of seconds also, when the scale is to be applied to a large telescope.

Fig. 21.

50. We shall therefore add some practical rules to render this micrometer useful to persons unacquainted with trigonometry and the use of logarithms.

Problem I. The angle, not exceeding one degree, which is subtended by an extension of one foot perpendicular to the axis of the telescope being given, to find its distance from the object-glass of the telescope.

Rule 1. If the angle be expressed in minutes, say, as the given angle is to 60, so is 687.55 to a fourth proportional, which gives the answer in inches.—2. If the angle be expressed in seconds, say, as the given angle is to 3600, so is 687.55 to a fourth proportional, which expresses the answer in inches.

Example. At what distance is a globe of one foot diameter when it subtends an angle of two seconds?

$$2'' : 3600'' :: 687.55 : \frac{3600 \times 687.55}{2} = 1237590$$

inches, or $103132\frac{1}{2}$ feet, which is the answer required.

Problem II. The angle, not exceeding one degree, which is subtended by any known extension, being given, to find its distance from the object-glass of the telescope.

Rule. Proceed as if the extension were of one foot by Problem I. and call the answer B; then, if the extension in question be expressed in inches, say, as 12 inches are to that extension, so is B to a fourth proportional, which is the answer in inches; but if the extension in question be expressed in feet, then you need only multiply it by B, and the product is the answer in inches.

Example. At what distance is a man six feet high, when he appears to subtend an angle of 30″.

By Problem I. if the man were one foot high, the distance would be 82506 inches; but as he is six feet high, therefore multiply 82506 by 6, and the product gives the required distance, which is 495036 inches, or 41253 feet.

For greater conveniency, especially in travelling, or in such circumstances in which one has not the opportunity of making even the easy calculations required in those problems, the following two tables have been computed; the first of which shows the distance answering to any angle from one minute to one degree, which is subtended by a man, the height of which has been called an extension of six feet; because, at a mean, such is the height of a man when dressed with a hat and shoes on.

Thus, if it is required to measure the extension of a street, let a foot ruler be placed at the end of the street; measure the angle it subtends, which suppose to be 36′, and in the table you will have the required distance opposite 36′, which is $95\frac{1}{2}$ feet. Thus also a man who appears to be 49′ high, is at the distance of 421 feet.

Angles subtended by an extension of one Foot at different Distances.

Angles.	Distances in Feet.	Angles	Distances in Feet.
Min. 1	3437.7	Min. 11	312.5
2	1718.9	12	286.5
3	1145.9	13	264.4
4	859.4	14	245.5
5	687.5	15	229.2
6	572.9	16	214.8
7	491.1	17	202.2
8	429.7	18	191.0
9	382.0	19	180.9
10	343.7	20	171.8

Angles

Micrometer.

Angles.	Distances in Feet.	Angles.	Distances in Feet.
Min. 21	162.7	Min. 41	83.8
22	156.2	42	81.8
23	149.4	43	79.9
24	143.2	44	78.1
25	137.5	45	76.4
26	132.2	46	74.7
27	127.3	47	73.1
28	122.7	48	71.6
29	118.5	49	70.1
30	114.6	50	68.7
31	110.9	51	67.4
32	107.4	52	66.1
33	104.2	53	64.8
34	101.1	54	63.6
35	98.2	55	62.5
36	95.5	56	61.4
37	92.9	57	60.3
38	90.4	58	59.2
39	88.1	59	58.2
40	85.9	60	58.3

Angles subtended by an Extension of six Feet at different Distances.

Angles.	Distances in Feet.	Angles.	Distances in Feet.
Min. 1	20626.8	Min. 31	665.4
2	10313.	32	644.5
3	6875.4	33	625.
4	5156.5	34	606.6
5	4125.2	35	589.3
6	3437.7	36	572.9
7	2946.6	37	557.5
8	2578.2	38	542.8
9	2291.8	39	528.9
10	2062.6	40	515.6
11	1875.2	41	503.1
12	1718.8	42	491.1
13	1586.7	43	479.7
14	1473.3	44	4688.
15	1375.	45	4584.
16	1298.1	46	448.4
17	1213.3	47	438.9
18	1145.9	48	429.7
19	1085.6	49	421.
20	1031.4	50	412.5
21	982.2	51	404.4
22	937.6	52	396.7
23	896.8	53	389.2
24	859 4	54	381.9
25	825.	55	375.
26	793.3	56	368.3
27	763.9	57	361.9
28	736.6	58	355.6
29	711.3	59	349.6
30	687.5	60	343.7

51. The following is the account of a micrometer invented by Mr Brewster, of the circumstances which led to the invention, and of its advantages. We shall give it in his own words *.

Mr Brewster's circular mother-of-pearl micrometer.

"In the winter of 1805 (he observes), when I was employed in delineating the surface of the moon, I wished to measure the diameter of the lunar spots by applying Mr Cavallo's micrometer to a thirty-inch achromatic telescope made by Berge. But as the eye-piece was moved by a rack and pinion, and consequently could not turn round its axis, the micrometer must have remained stationary, and could only measure angles in one direction. This difficulty, indeed, might have been surmounted by a mechanical contrivance for turning the diaphragm about its centre, or more simply by giving a motion of rotation to the tube which contains the third and fourth eye-glasses. Such a change in the eye-piece, however, was both inconvenient and difficult to be made. Mr Cavallo's micrometer, therefore, has this great disadvantage, that it cannot be used in reflecting telescopes, or in any achromatic telescope where the adjustment of the eye-piece is effected by rackwork, unless the structure of these instruments is altered for the purpose. Another disadvantage of this micrometer arises from the slip of mother-of-pearl passing through the centre of the field. The picture in the focus of the eye-glass is broken into two parts, and the view is rendered still more unpleasant by the inequality of the segments into which the field is divided. In addition to these disadvantages, the different divisions of the micrometer are at unequal distances from the eye-glass which views them, and therefore can neither appear equally distinct nor subtend equal angles at the eye.

* *Phil. Mag.* vol. xxix. p. 48.

"Finding that Mr Cavallo's instrument laboured under these imperfections, I thought of a circular mother-of-pearl micrometer which is free from them all, and has likewise the advantage of a kind of diagonal scale, increasing in accuracy with the angle to be measured. This micrometer, which I got executed by Miller and Adie, optical instrument-makers in Edinburgh, and which I have often used, both in determining small angles in the heavens and such as are subtended by terrestrial objects, is represented in fig. 27. which exhibits its appearances in the focus of the fourth eye-glass. The black ring, which forms part of the figure, is the diaphragm, and the remaining part is a ring of mother-of-pearl, having its interior circumference divided into 360 equal parts. The mother-of-pearl ring, which appears connected with the diaphragm, is completely separate from it, and is fixed at the end of a brass tube which is made to move between the third eye-glass and the diaphragm, so that the divided circumference may be placed exactly in the focus of the glass next the eye. When the micrometer is thus fitted into the telescope, the angle subtended by the whole field of view, or by the diameter of the innermost circle of the micrometer, must be determined either by measuring a base or by the passage of an equatoreal star, and the angles subtended by any number of divisions or degrees will be found by a table constructed in the following manner.

Plate CCCXXXVI. Fig. 27.

52. "Let $AmpnB$, fig. 28. be the interior circumference of the micrometer scale, and let $m\,n$ be the object to be measured. Bisect the arch $m\,n$ in p, and draw $C\,m$, $C\,p$, $C\,n$. The line $C\,p$ will be at right angles to $m\,n$, and therefore $m\,n$ will be twice the sine of half the arch $m\,n$. Consequently, AB : $m\,n$ = rad. sine of $\frac{1}{2}\,m\,p\,n$;

Fig. 28.

Micrometer.

$\frac{1}{2} mpn$; therefore $mn \times R = \sin.\ \frac{1}{2} mpn \times AB$, and $mpn = \frac{\sin.\ \frac{1}{2} mpn \times AB}{R} = \frac{\sin.\ \frac{1}{2} mpn}{R} \times AB$; a formula by which the angle subtended by the chord of any number of degrees may be easily found. The first part of the formula, viz. $\frac{\sin\ \frac{1}{2} mpn}{R}$ is constant, while AB varies with the size of the micrometer and with the magnifying power which is applied. We have therefore computed the following table, containing the value of the constant part of the formula for every degree or division of the scale.

Deg.	Constant Part of the Formula	Deg.	Constant Part.	Deg.	Constant Part	Deg.	Constant Part.
1	.0087	46	.3907	91	.7133	136	.9272
2	.0174	47	.3987	92	.7193	137	.9304
3	.0262	48	.4067	93	.7254	138	.9336
4	.0349	49	.4147	94	.7314	139	.9367
5	.0436	50	.4226	95	.7373	140	.9397
6	.0523	51	.4305	96	.7431	141	.9426
7	.0610	52	.4384	97	.7490	142	.9455
8	.0698	53	.4462	98	.7547	143	.9483
9	.0785	54	.4540	99	.7604	144	.9511
10	.0872	55	.4617	100	.7660	145	.9537
11	.0958	56	.4695	101	.7716	146	.9563
12	.1045	57	.4771	102	.7771	147	.9588
13	.1132	58	.4848	103	.7826	148	.9613
14	.1219	59	.4924	104	.7880	149	.9636
15	.1305	60	.5000	105	.7934	150	.9659
16	.1392	61	.5075	106	.7986	151	.9681
17	.1478	62	.5150	107	.8039	152	.9703
18	.1564	63	.5225	108	.8090	153	.9724
19	.1650	64	.5299	109	.8141	154	.9744
20	.1736	65	.5373	110	.8192	155	.9763
21	.1822	66	.5446	111	.8241	156	.9781
22	.1908	67	.5519	112	.8290	157	.9799
23	.1994	68	.5592	113	.8339	158	.9816
24	.2079	69	.5664	114	.8387	159	.9833
25	.2164	70	.5735	115	.8434	160	.9848
26	.2250	71	.5807	116	.8480	161	.9863
27	.2334	72	.5878	117	.8526	162	.9877
28	.2419	73	.5948	118	.8572	163	.9890
29	.2504	74	.6018	119	.8616	164	.9903
30	.2588	75	.6088	120	.8660	165	.9914
31	.2672	76	.6157	121	.8704	166	.9925
32	.2756	77	.6225	122	.8746	167	.9936
33	.2840	78	.6293	123	.8788	168	.9945
34	.2923	79	.6361	124	.8829	169	.9954
35	.3007	80	.6428	125	.8870	170	.9962
36	.3090	81	.6494	126	.8910	171	.9969
37	.3173	82	.6561	127	.8949	172	.9976
38	.3256	83	.6626	128	.8988	173	.9981
39	.3338	84	.6691	129	.9026	174	.9986
40	.3420	85	.6756	130	.9063	175	.9990
41	.3502	86	.6820	131	.9100	176	.9994
42	.3584	87	.6884	132	.9135	177	.9996
43	.3665	88	.6947	133	.9171	178	.9998
44	.3746	89	.7009	134	.9205	179	1.0000
45	.3827	90	.7071	135	.9239	180	1.0000

53. "In order to find the angle subtended by any number of degrees, we have only to multiply the constant part of the formula corresponding to that number in the table by AB, or the angle subtended by the whole field. Thus if AB is 30 minutes, as it happens to be in the micrometer which I have constructed, the angle subtended by 1 degree of the scale will be $30' \times .009 = 16\frac{2}{5}$ seconds, and the angle subtended by 40 degrees will be $30' \times .342 = 10'\ 15.6''$; and by making the calculation it will be found that as the angle to be measured increases, the accuracy of the scale also increases; for when the arch is only 1 or 2 degrees, a variation of 1 degree produces a variation of about 16 seconds in the angle; whereas when the arch is between 170 and 180, the variation of a degree does not produce a change much more than one second in the angle. This is a most important advantage in the circular scale, as in Cavallo's micrometer a limit is necessarily put to the size of the divisions.

"It is obvious, from an inspection of fig. 27. that there is no occasion for turning the circular micrometer round its axis, because the divided circumference lies in every possible direction. In fig. 2. for example, if the object has the direction *a b* it will be measured by the arch *a o b*, and if it lies in the line *c d* it will be measured by the arch *c r d*.

"In the circular micrometer which I have been in the habit of using, AB, or the diameter of the field of view, is exactly half an inch, the diameter of the brass tube in which it is fixed is one inch, the length of the tube half an inch, and the degrees of the divided circumference $\frac{1}{230}$ of an inch.

Application of the micrometer to microscopes.

54. II. The micrometer has not only been applied to telescopes, and employed for astronomical purposes; but there have also been various contrivances for adapting it to MICROSCOPICAL observations. Mr Leeuwenhoeck's method of estimating the size of small objects was by comparing them with grains of sand, of which 100 in a line took up an inch. These grains he laid upon the same plate with his objects, and viewed them at the same time. Dr Jurin's method was similar to this; for he found the diameter of a piece of fine silver wire, by wrapping it as close as he could about a pin, and observing how many rings made an inch; and he used this wire in the same manner as Leeuwenhoeck employed his sand. Dr Hooke looked upon the magnified object with one eye, while at the same time he viewed other objects placed at the same distance with the other eye. In this manner he was able, by the help of a ruler, divided into inches and small parts, and laid on the pedestal of the microscope, to cast as it were the magnified appearance of the object upon the ruler, and thus exactly to measure the diameter which it appeared to have through the glass; which being compared with the diameter as it appeared to the naked eye, showed the degree in which it was magnified.

55. Mr Martin * recommended such a micrometer for a microscope as had been applied to telescopes: for he advises to draw a number of parallel lines on a piece of glass, with the fine point of a diamond, at the distance of one-fortieth of an inch from one another, and to place it in the focus of the eye-glass. By this method, Dr Smith contrived to take the exact draught of objects viewed by a double microscope; for he advises

* *Martin's Optics*, p. 277.

Micrometer.

to get a lattice, made with small silver wires or squares drawn upon a plain glass by the strokes of a diamond, and to put it into the place of the image, formed by the object-glass: then by transferring the parts of the object, seen in the squares of the glass or lattice upon similar corresponding squares drawn on paper, the picture may be exactly taken. Mr Martin also introduced into compound microscopes another micrometer, consisting of a screw.

† *Microscopical Essays*, p. 59.

56. The mode of actual admeasurement (Mr Adams observes †) is without doubt the most simple that can be used; as by it we comprehend, in a manner, at one glance, the different effects of combined glasses; and as it saves the trouble, and avoids the obscurity of the usual modes of calculation: but many persons find it exceedingly difficult to adopt this method, because they have not been accustomed to observe with both eyes at once. To obviate this inconvenience, the late Mr Adams contrived an instrument called the *Needle-Micrometer*, which was first described in his *Micrographia Illustrata;* and of which, as now constructed, we have the following description by his son Mr George Adams in the ingenious Essays above quoted.

This micrometer consists of a screw, which has 50 threads to an inch; this screw carries an index, which points to the divisions on a circular plate, which is fixed at right angles to the axis of the screw. The revolutions of the screw are counted on a scale, which is an inch divided into 50 parts; the index to these divisions is a flower-de-luce marked upon the slider, which carries the needle point across the field of the microscope. Every revolution of the micrometer screw measures $\frac{1}{50}$th part of an inch, which is again subdivided by means of the divisions on the circular plate, as this is divided into 20 equal parts, over which the index passes at every revolution of the screw; by which means we obtain with ease the measure of 1000th part of an inch: for 50, the number of threads on the screw in one inch, being multiplied by 20, the divisions on the circular plate are equal to 1000; so that each division on the circular plate shows that the needle has either advanced or receded 1000th part of an inch.

Fig. 25.

57. To place this micrometer on the body of the microscope, open the circular part FKH, fig. 25. by taking out the screw G, throw back the semicircle FK, which moves upon a joint at K; then turn the sliding tube of the body of the microscope, so that the small holes which are in both tubes may exactly coincide, and let the needle g of the micrometer have a free passage through them; after this, screw it fast upon the body by the screw G. The needle will now traverse the field of the microscope, and measure the length and breadth of the image of any object that is applied to it. But further assistance must be had, in order to measure the object itself, which is a subject of real importance; for though we have ascertained the power of the microscope, and know that it is so many thousand times, yet this will be of little assistance towards ascertaining an accurate idea of its real size; for our ideas of bulk being formed by the comparison of one object with another, we can only judge of that of any particular body, by comparing it with another whose size is known: the same thing is necessary, in order to form an estimate by the microscope; therefore, to ascertain the real measure of the object, we must make the point of the needle pass over the image of a known part of an inch placed on the stage, and write down the revolutions made by the screw, while the needle passed over the image of this known measure; by which means we ascertain the number of revolutions on the screw, which are adequate to a real and known measure on the stage. As it requires an attentive eye to watch the motion of the needle point as it passes over the image of a known part of an inch on the stage, we ought not to trust to one single measurement of the image, but ought to repeat it at least six times; then add the six measures thus obtained together, and divide their sum by six, or the number of trials; the quotient will be the mean of all the trials. This result is to be placed in a column of a table next to that which contains the number of the magnifiers.

Fig. 22, 23, 24.

58. By the assistance of the sectoral scale, we obtain with ease a small part of an inch. This scale is shown at fig. 22, 23, 24, in which the two lines $c\,a$, $c\,b$, with the side $a\,b$, form an isosceles triangle; each of the sides is two inches long, and the base still only of one-tenth of an inch. The longer sides may be of any given length, and the base still only one-tenth of an inch. The longer lines may be considered as the line of lines upon a sector opened to one-tenth of an inch. Hence whatever number of equal parts $c\,a$, $c\,b$ are divided into, their transverse measure will be such a part of one-tenth as is expressed by their division. Thus if it be divided into ten equal parts, this will divide the inch into 100 equal parts; the first division next c will be equal to 100th part of an inch, because it is the tenth part of one-tenth of an inch. If these lines are divided into twenty equal parts, the inch will be by that means divided into 200 equal parts. Lastly, if $a\,b$, $c\,a$, are made three inches long, and divided into 100 equal parts, we obtain with ease the 1000th part. The scale is represented as solid at fig. 23. but as perforated at fig. 22. and 24. so that the light passes through the aperture, when the sectoral part is placed on the stage.

59. To use this scale, first fix the micrometer, fig. 25. to the body of the microscope; then fit the sectoral scale, fig. 24. in the stage, and adjust the microscope to its proper focus or distance from the scale, which is to be moved till the base appears in the middle of the field of view; then bring the needle point g, fig. 25. (by turning the screw L) to touch one of the lines $c\,a$, exactly at the point answering to 20 on the sectoral scale. The index a of the micrometer is to be set to the first division, and that on the dial plate to 20, which is both the beginning and end of its divisions; we are then prepared to find the magnifying power of every magnifier in the compound microscope which we are using.

60. *Example.* Every thing being prepared agreeable to the foregoing directions, suppose you are desirous of ascertaining the magnifying power of the lens marked N° 4. turn the micrometer screw until the point of the needle has passed over the magnified image of the tenth part of one inch; then the division, where the two indices remain, will show how many revolutions, and parts of a revolution, the screw has made, while the needle point traversed the magnified image of the one-tenth of an inch; suppose the result to be 26 revolutions

Micrometer.

volutions of the screw, and 14 parts of another revolution, this is equal to 26 multiplied by 20, added to 14; that is, 534,000 parts of an inch. The 26 divisions found on the straight scale of the micrometer, while the point of the needle passed over the magnified image of one-tenth part of an inch, were multiplied by 20, because the circular plate CD, fig. 25. is pivided into 20 equal parts; this produced 520; then adding the 14 parts of the next revolution, we obtain the 534,000 parts of an inch, or five-tenths and 3400 parts of another tenth, which is the measure of the magnified image of one-tenth of an inch, at the aperture of the eye-glasses or at their foci. Now if we suppose the focus of the two eye-glasses to be one inch, the double thereof is two inches; or if we reckon in the 1000th part of an inch, we have 2000 parts for the distance of the eye from the needle point of the micrometer. Again, if we take the distance of the image from the object at the stage at 6 inches, or 6000, and add thereto 2000, double the distance of the focus of the eye-glass, we shall have 8000 parts of an inch for the distance of the eye from the object; and as the glasses double the image, we must double the number 534 found upon the micrometer, which then makes 1068; then, by the following analogy, we shall obtain the number of times the microscope magnifies the diameter of the object; say, as 240, the distance of the eye from the image of the object, is to 800, the distance of the eye from the object; so is 1068, double the measure found on the micrometer, to 3563, or the number of times the microscope magnifies the diameter of the object. By working in this manner, the magnifying power of each lens used with the compound microscope may be easily found, though the result will be different in different compound microscopes, varying according to the combination of the lenses, their distance from the object and one another, &c.

Fig. 25.

61. Having discovered the magnifying power of the microscope, with the different object-lenses that are used therewith, our next subject is to find out the real size of the objects themselves, and their different parts: this is easily effected, by finding how many revolutions of the micrometer screw answer to a known measure on the sectoral scale or other object placed on the stage; from the number thus found, a table should be constructed, expressing the value of the different revolutions of the micrometer with that object lens, by which the primary number was obtained. Similar tables must be constructed for each object lens. By a set of tables of this kind, the observer may readily find the measure of any object he is examining; for he has only to make the needle point traverse over this object, and observe the number of revolutions the screw has made in its passage, and then look into his table for the real measure which corresponds to this number of revolutions, which is the measure required.

Description of Mr Coventry's micrometers for microscopes.

62. Mr Coventry of Southwark has favoured us with the description of a micrometer of his own invention; the scale of which, for minuteness, surpasses every instrument of the kind of which we have any knowledge, and of which, indeed, we could scarcely have formed a conception, had he not indulged us with several of these instruments, graduated as underneath.

The micrometer is composed of glass, ivory, silver, &c. on which are drawn parallel lines from the 10th to the 10,000th part of an inch. But an instrument thus divided, he observes, is more for curiosity than use: but one of those which Mr Coventry has sent us is divided into squares, so small that sixteen millions of them are contained on the surface of one square inch, each square appearing under the microscope true and distinct; and though so small, it is a fact, that animalcula are found which may be contained in one of these squares.

The use of micrometers, when applied to microscopes, is to measure the natural size of the object, and how much that object is magnified. To ascertain the real size of an object in the single microscope, nothing more is required than to lay it on the micrometer, and adjust it to the focus of the magnifier, noticing how many divisions of the micrometer it covers. Suppose the parallel lines of the micrometer to be the 1000th of an inch, and the object covers two divisions; its real size is 500ths of an inch; if five, 200ths, and so on.

But to find how much the object is magnified, is not mathematically determined so easily by the single as by the compound microscope: but the following simple method (says Mr Coventry) I have generally adopted, and think it tolerably accurate. Adjust a micrometer under the microscope *o*, say the 100th of an inch of divisions, with a small object on it; if square, the better: notice how many divisions one side of the object covers, suppose 10: then cut a piece of white paper something larger than the magnified appearance of the object: then fix one eye on the object through the microscope, and the other at the same time on the paper, lowering it down till the object and the paper appear level and distinct: then cut the paper till it appear exactly the size of the magnified object; the paper being then measured, suppose an inch square: Now, as the object under the magnifier, which appeared to be one inch square, was in reality only ten hundredths, or the tenth of an inch, the experiment proves that it is magnified ten times in length, one hundred times in superfices, and one thousand times in cube, which is the magnifying power of the glass; and, in the same manner, a table may be made of the power of all the other glasses.

In using the compound microscope, the real size of the object is found by the same method as in the single: but to demonstrate the magnifying power of each glass to greater certainty, adopt the following method.—Lay a two-feet rule on the stage, and a micrometer level with its surface (an inch suppose, divided into 100 parts): with one eye see how many of those parts are contained in the field of the microscope, suppose 50); and with the other, at the same time, look for the circle of light in the field of the microscope, which with a little practice will soon appear distinct; mark how much of the rule is intersected by the circle of light, which will be half the diameter of the field. Suppose eight inches; consequently the whole diameter will be sixteen. Now, as the real size of the field, by the micrometers, appeared to be only 50 hundredths, or half an inch, and as half an inch is only one 32d part

Micrometer.

part of 16 inches, it shows the magnifying power of the glass to be 32 times in length, 1024 superfices, and 32,768 cube (E).

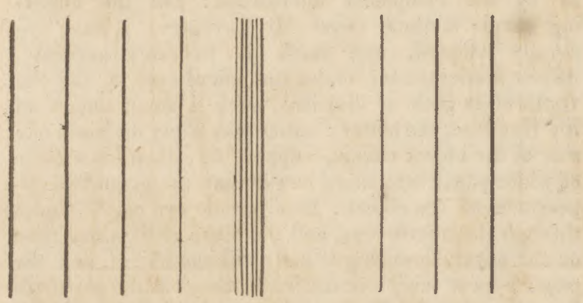
63. Another way of finding the magnifying power of compound microscopes, is by using two micrometers of the same divisions; one adjusted under the magnifier, the other fixed in the body of the microscope in the focus of the eye-glass. Notice how many divisions of the micrometer in the body are seen in one division of the micrometer under the magnifier, which again must be multiplied by the power of the eye-glass. Example: Ten divisions of the micrometer in the body are contained in one division under the magnifier; so far the power is increased ten times: now, if the eye-glass be one inch focus, such glass will of itself magnify about seven times in length, which, with the ten times magnified before, will be seven times ten, or 70 times in length, 4900 superfices, and 343,000 cube.

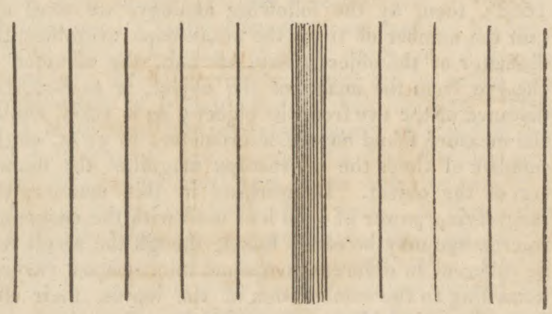
"If (says Mr Coventry) these micrometers are employed in the solar microscope, they divide the object into squares on the screen in such a manner as to render it extremely easy to make a drawing of it. And (says he) I apprehend they may be employed to great advantage with such a microscope as Mr Adam's lucernal; because this instrument may be used either by day or night, or in any place, and gives the actual magnifying power without calculation."

Micrometer, Micropus.

The case with which we have been favoured by Mr Coventry contains six micrometers, two on ivory and four on glass. One of those on ivory is an inch divided into one hundred parts, every fifth line longer than the intermediate ones, and every tenth longer still, for the greater ease in counting the divisions under the microscope, and is generally used in measuring the magnifying power of microscopes. The other ivory one is divided into squares of the 50th and 100th of an inch, and is commonly employed in measuring opaque objects.

Those made of glass are for transparent objects, which, when laid on them, show their natural size.—That marked on the brass 100, are squares divided to the 100th of an inch: that marked 5000 are parallel lines forming nine divisions, each division the 1000th of an inch; the middle division is again divided into 5, making divisions to the 5000th of an inch. That marked 10,000 is divided in the same manner, with the middle division divided into 10, making the 10,000th of an inch. Example:





The glass micrometer without any mark is also divided, the outside lines into 100th, the next into 1000th, and the inside lines into the 4000th of an inch: these are again crossed with an equal number of lines in the same manner, making squares of the 100th, 1000th, and 4000th of an inch, thus demonstrating each other's size. The middle square of the 1000th of an inch (see fig. 26.) is divided into sixteen squares; now as 1000 squares in the length of an inch, multiplied by 1000, gives one million in an inch surface; by the same rule, one of those squares divided into 16 must be the sixteen millionth parth of an inch surface. See fig. 26. which is a diminished view of the apparent surface exhibited under the magnifier N° 1. of Wilson's microscope. In viewing the smallest lines, Mr Coventry uses N° 2. or 3.; and they are all better seen, he says, by candle than by day-light.

MICROPUS, Bastard Cudweed; a genus of plants belonging to the syngenesia class, and in the natural method ranking under the 49th order, *Compositæ*. See Botany *Index*.

(E) It will be necessary, for great accuracy, as well as for comparative observations, that the two-feet rule should always be placed at a certain distance from the eye; eight inches would, in general, be a proper distance.

END OF THE THIRTEENTH VOLUME.

Fig. 1.

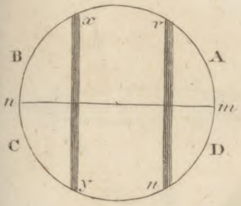


Fig. 3.

Fig. 8.

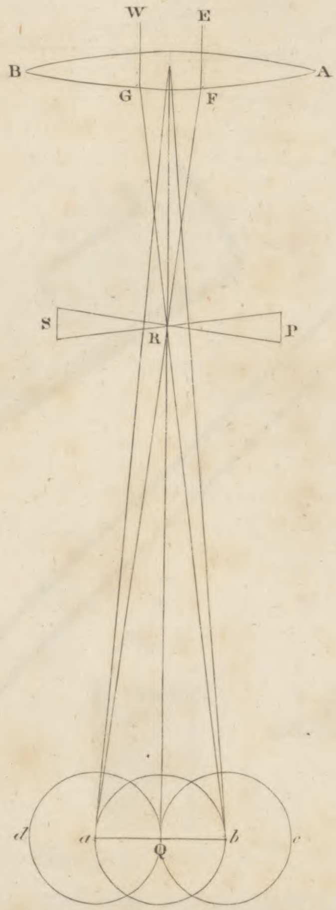


Fig. 9.

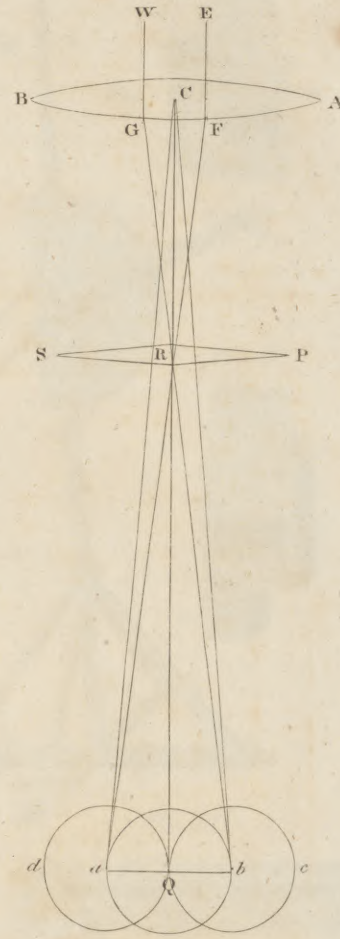


Fig. 4.

Fig. 5.

Fig. 6.

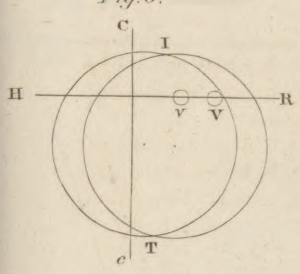


Fig. 10.

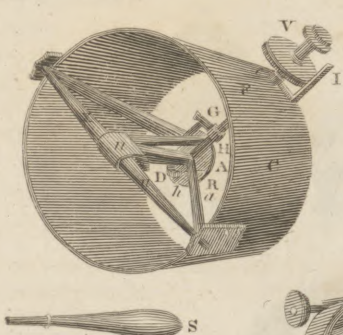


Fig. 2.

Fig. 11.

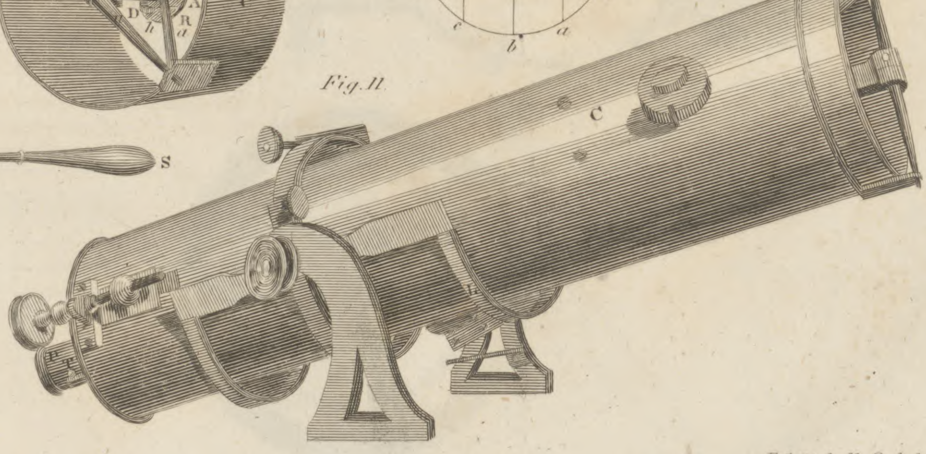
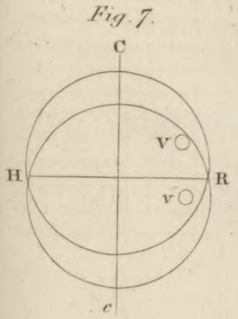
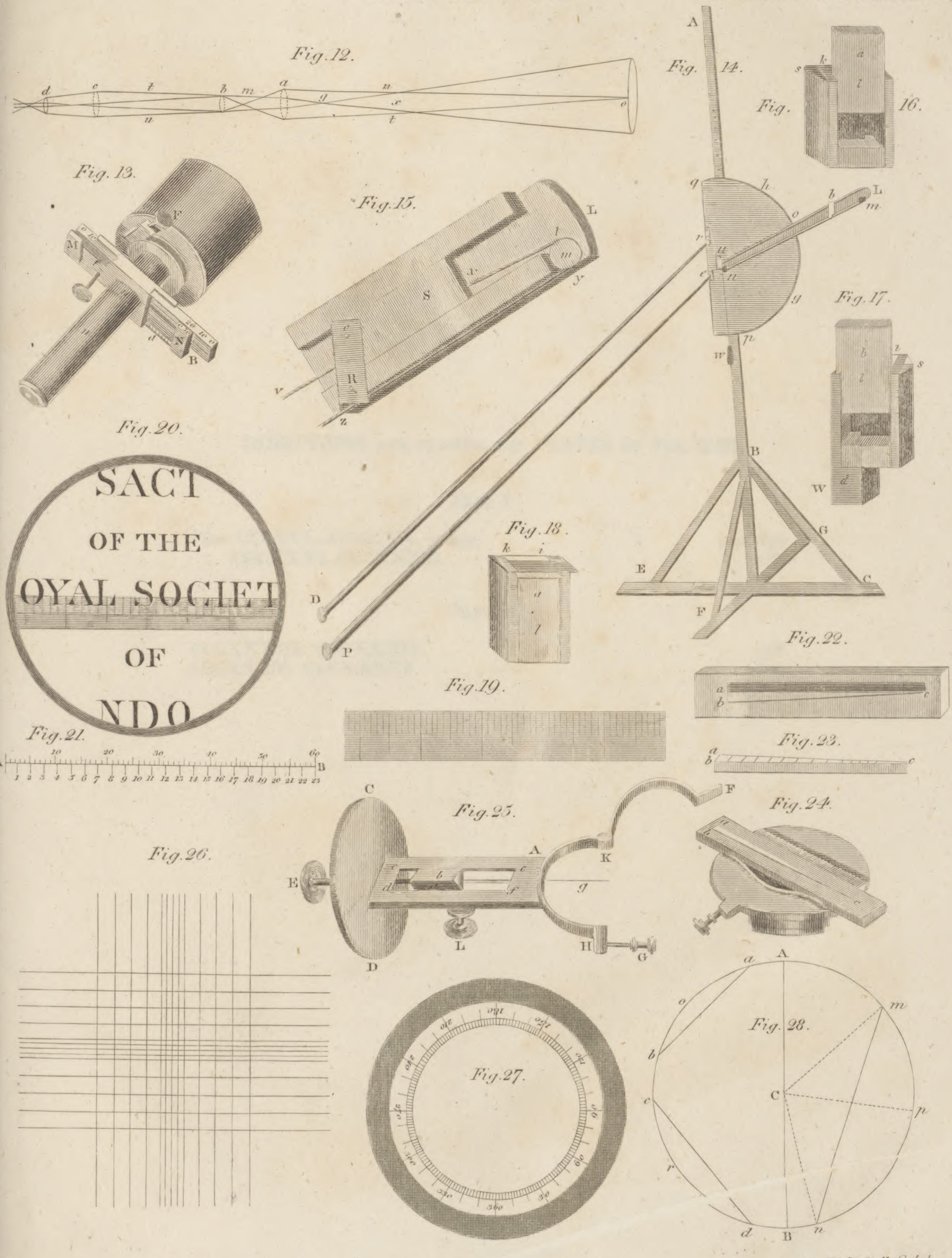


Fig. 7.



E. Mitchell sculp.



E. Mitchell sculp.

DIRECTIONS FOR PLACING THE PLATES OF VOL. XIII.

PART I.

PART II.